# The influence of coating on general and reference printing conditions

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**Abstract**

The sheetfed printing industry is having commercial pressure applied to it from its customers to produce higher quality product at a lower cost. As a consequence, the use of inline coatings is increasing throughout the industry to improve product appearance, durability and to give *"added value"* to the product. This addition of a secondary layer on top of the print causes problems in both the proofing and to the appearance of the print. Often proofing has to be carried out at the press side and it has been reported that the use of the coatings can introduce tone jumps within the gradation scale.

This paper assesses the influence of coatings on the print quality. Prints have been produced to the set specifications and then coated. The coatings assessed within the experimental programme include both aqueous and UV of different appearances. The results show the effect of the coating on the print quality in terms of the color, tonal reproduction and appearance.

## Introduction

The use of coatings is increasing in popularity in the production of printed product. There are many reasons these coatings are introduced, two of the main reasons that are related to appearance and product protection. The use of a coating can also significantly alter the gloss level of the product. The changes in gloss levels can be applied either locally or globally. This can help to differentiate the product and therefore provide added value to the customer.

These coatings can in certain instances affect both the visual appearance of the products and the measured values obtained. The objective of this investigation is to evaluate the magnitude of these changes within a controlled experimental

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program. There are many cases, Figure 1 for example, in which a color shift is attributed to the coating. However, it is difficult to determine if these differences are due to either a change in the underlying print or as a direct result of the coating application.

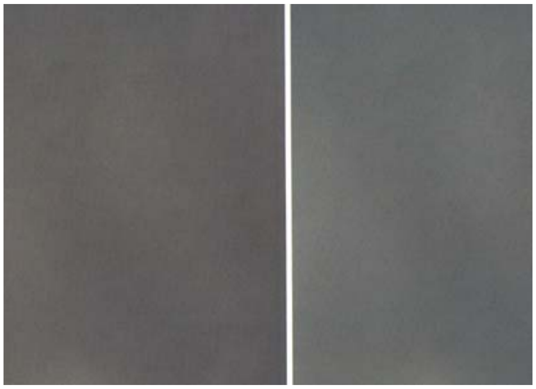

Figure 1: The effect of coating on color

## Experimental procedure

The objective of the investigation was to evaluate the impact of coating on the appearance and measurements made on a print produced using a sheet fed press. The investigation used aqueous and UV coatings, these are used in many commercial applications and represent coatings typically in use. Coatings were obtained of the three types of finish in common use, namely gloss, matte and satin. To complete the variable selection, two substrate types were used, a gloss and matte coated sheet. They could be used to asses the interaction between the paper characteristics and different coating conditions. All combinations were evaluated and the experimental trials are shown in Table 1.

To apply aqueous coatings in line they are applied over a conventional ink set. However, the application of UV coatings in line over conventional inks can give rise to print problems and if this combination is necessary a primer is used (intermediate coating) to separate the ink from the coating. The UV coatings are applied over UV or increasing commonly over hybrid ink sets. For this investigation hybrid inks were used with the UV coating applied in line.

| Paper | Coating | Ink |
|---|---|---|
| | | |
| Gloss paper | Uncoated | Conventional |
| Matte paper | Uncoated | Conventional |
| Gloss paper | Aqueous gloss coating | Conventional |
| Gloss paper | Aqueous matte coating | Conventional |
| Gloss paper | Aqueous satin coating | Conventional |
| Matte paper | Aqueous gloss coating | Conventional |
| Matte paper | Aqueous matte coating | Conventional |
| Matte paper | Aqueous satin coating | Conventional |
| Gloss paper | Uncoated | Hybrid |
| Matte paper | Uncoated | Hybrid |
| Gloss paper | UV gloss coating | Hybrid |
| Gloss paper | UV matte coating | Hybrid |
| Gloss paper | UV satin coating | Hybrid |
| Matte paper | UV gloss coating | Hybrid |
| Matte paper | UV matte coating | Hybrid |
| Matte paper | UV satin coating | Hybrid |

Table 1: Experimental conditions assessed

The prints were produced on a Komori L628 press to a standard density; the values used are shown in Table 2. These were determined during initial pre trial print runs to evaluate the ink / paper combinations. They produced a good neutral grey and the tonal reproduction values were close to the targets in standards specifications. The ink trapping of the two ink sets used were different, with the trap values obtained from the hybrid ink being lower than that from the conventional. Therefore, when the densities and tonal reproduction matched, the overprints and grays did not. For a comparison it was concluded that it would be ideal that the images matched. To achieve this, the plates for the hybrid ink were curved slightly differently, having a slightly different tonal reproduction for the same target density.

| Color | Black | Cyan | Magenta | Yellow | Reflex Blue |
|---|---|---|---|---|---|
| Density | 1.75 | 1.32 | 1.49 | 0.99 | 1.75 |

Table 2: Target densities for the print runs

The printed product was measured immediately it was delivered onto the delivery using a press side scanning spectrodensitometer. Considerable time was spent ensuring that the densities were very close to the target specification. The objective was that the ink densities should be with ±0.02 density units. This was achieved but resulted in considerable waste being produced.

The coater configuration used in the investigation was a chambered anilox system. The coating was applied after the printing stations. Using this type of coater, the coat weight is determined primarily by the volume of the anilox roll used. Changes in thickness are achieved by altering the viscosity of the coating fluid and this is commonly affected by changing the temperature of the coating fluid. Increases in the temperature will result in a lower fluid viscosity. The volume of the anilox roll used in this investigation is 12 BCM. The coating is pumped to into the coating head, which is an enclosed chamber.

The image used is shown in Figure 2, two of these were printed side by side on the sheet. The main features of the form included images for visual assessment of the prints, gradation scales to evaluate the tone gain, large solid color blocks for gloss and print uniformity. There were also series halftone blocks taken from the IT8 color target to evaluate color differences and grey balance bars to evaluate uniformity across the sheet. An identical color control strip was placed at both the leading and trailing edge of the sheet. The use of the two test strips allowed the measurement of the effect of coating on the density to be assessed on each sheet as the coating was applied to the leading edge test strip while the one at the trailing edge was uncoated. This was achieved by undercutting the blanket on the coating unit.

The test strips located at the leading and trailing edge of the sheet were measured with a scanning spectrophotometer to obtain both the density and color data. For each of the conditions fifteen samples were measured and averaged to produce an average values.

The gloss of the samples was measured using a gloss meter with a 20/60/85 degree geometry. This took multiple angle readings simultaneously. For each of the conditions, fifteen samples were measured and averaged to produce an average gloss measurement. The measurements were recorded for the appropriate angle for the different gloss levels. The gloss levels of the samples varied dramatically, dependent on the coating applied. Measurements were taken in all cases at $60^0$. This is ideal for the semi gloss samples, with gloss readings between 10 and 70 gloss units. The high gloss reading above 70, the $20^0$ geometry readings were also recorded as these are appropriate for high gloss. When the gloss level at $60^0$ was lower than 30, the $85^0$ geometry readings were also recorded as these are appropriate for low gloss. The measurements were made on the paper between the two images and over each of the large solid blocks.


Figure 2: Image used for trial

## Results and discussion

The results will be presented in several sections, starting with the visual assessment of the prints. This is followed by a discussion of the effect of the coatings on the gloss levels of both the printed and unprinted material. The measured effects on the density, tonal reproduction and finally color are then presented and discussed.

The visual assessment of the prints was carried out in two parts. Initial visual assessment evaluated the sequential variation between prints from the same run. As would be expected, this variation was not visible. The prints were then compared in groups dependent on the substrate type and ink. In each case, the coated prints were compared to the uncoated. This resulted in four sets of four being evaluated.

The analysis of the results from this visual assessment showed there was only a small difference in the appearance of the prints due to the application of the coating. This variation was lower than predicted from other work and industry practices. This may be in part due to the very tight control applied to the printed ink density.

The visual evaluation of the conventional ink on gloss paper sample set indicated that there was a small difference from the uncoated sheet, with the coated samples appearing to have a red cast, most noticeable in the bridge image, Figure 2. There was no appreciable difference between any of the coatings. With the matte paper sample set, the color differences were larger than those observed and the color shift also altered. The coating caused a green color shift, with the satin coating having the largest effect.

The visual evaluation of the UV coatings on the hybrid ink sample set showed only small visual changes in the print, similar to the conventional ink in magnitude. The coatings on the gloss paper giving a green cast, with consistency between the coating types. With the matte paper sample set, the color shift was again more noticeable and there was not only a red color shift, but also a change in the luminance, with the green areas appearing darker. Throughout all the visual assessment the changes were minimal and would be classed as *"commercially acceptable"*.

The gloss was measured using the multiple angle gloss meter. These were measured some time after the prints had been produced. They were measured over each of the large ink solids, Figure 2, and in the unprinted area between the two print forms. For ease of comparison, the gloss as 60 degrees only will be presented, as there were wide ranges of gloss levels produced and measured during the investigation.

The results have been grouped by substrate / ink type and those for the conventional ink on gloss paper are shown in Figure 3. The gloss coating increased the measured gloss level slightly, while there is a reduction with both the satin and matte coatings. The results with the satin coating showed inconsistency, with smaller effects on the black ink and also for the paper. The gloss levels produced during the trials were representative of those that would be produced by aqueous coatings, allowing for the coatings to dry.

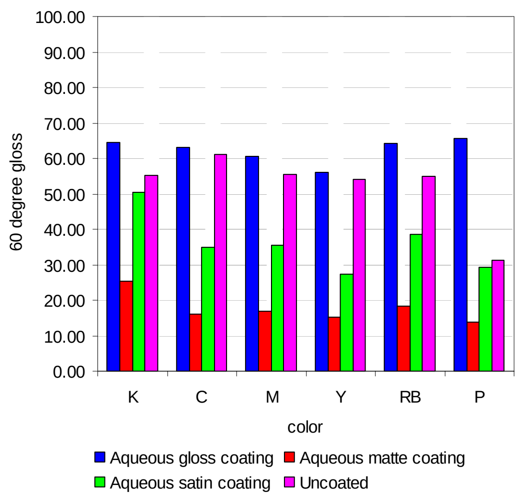


Figure 3: Gloss measurements for aqueous inline coating on gloss paper

The measured gloss levels were greatly reduced on the matte paper, with the paper reading ≈29 GU at 85 degrees. The gloss coating increases the gloss level, but these are low at less than 30 GU with the 60 degree measurement. Both the satin and matte coatings reduce the gloss levels of the ink areas. Considering the paper, all the coatings increased the gloss level.

The application of the UV coatings increased the gamut of gloss that could be achieved; most notably much higher gloss values could be reached using the UV gloss coating, Figure 4. These were approximately 25 GU higher, when compared to the aqueous coating. In addition, slightly lower gloss values were achieved with the matte coatings. The consistency of the gloss levels across the colors is more consistent with the UV coating. The lower gloss levels of the uncoated ink samples are a result of the change in the split dynamics at the nip contact and also the faster drying of the ink using the UV lamps reducing the ability of the ink to level.

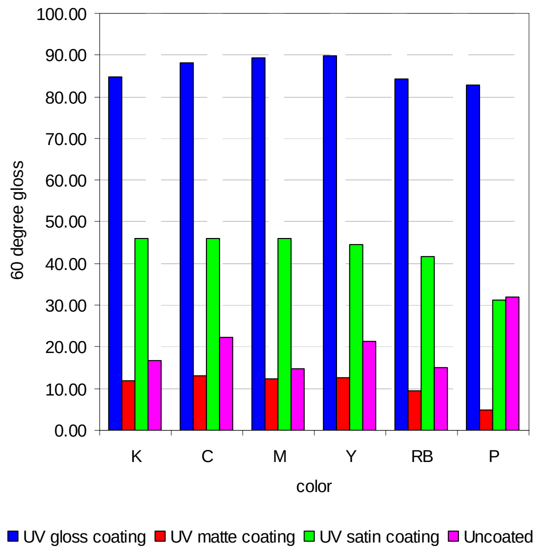


Figure 4: Gloss measurements for UV inline coating on gloss paper

During the run, the prints were immediately removed from the print delivery stack and measured using a scanning spectrophotometer. This was used to ensure the consistency of the printed product, with the prints produced to the same target densities. However, there was a significant amount of dry back / gloss back occurring in the prints. This resulted in there being a difference between the target density and the density once the sheet had been allowed to dry. This was large and fast acting. It could be measured on the press by carrying out repeat measurements on the same print. Changes between 0.05 / 0.10 density units in approximately 10 minutes were identified. Typical results of this dry back / gloss back are shown in Figure 5. The largest changes were detected for the black and reflex blue inks. The density reduction was also greater for the matte paper. *Note: the reflex blue density have been measured for the cyan values.*

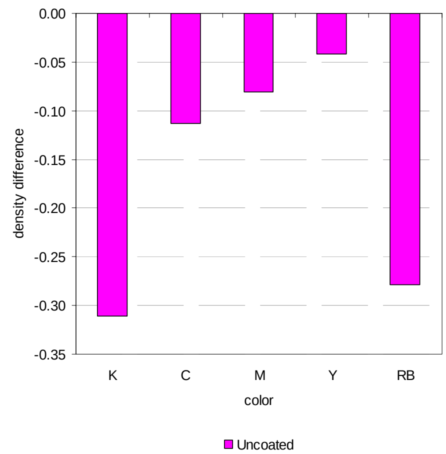


Figure 5: Change in density from target; gloss paper, conventional ink.

The inclusion of two test strips, one coated and the other not allowed this change in density to be compensated for. With all sheetfed presses there will be a variation of density around the circumference of the printing form. This is consistent; it can be measured and adjusted for if required. It will alter slightly with each ink / paper combination, but is essentially the same. The measured results of this variation are shown in Figure 6, for one of the combinations. This data was used to normalize all the subsequent comparisons between the coated and uncoated measurements for each ink / paper combination.

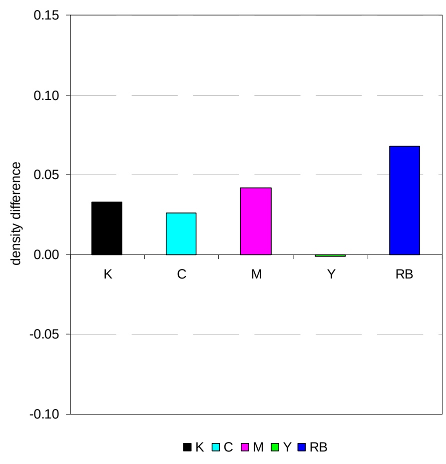


Figure 6: Typical difference between lead and trail edge, matte paper, hybrid ink

The results presented are compensated for the dry back, as indicated in the earlier discussion. The results are plotted as density difference between the coated and uncoated test strip, normalized for the difference between the lead and trailing edges of the print. A positive density difference indicates that the coated sample has a higher density, while a negative density difference indicates that the uncoated sample has a higher density.

The aqueous coatings have a significant effect on the measured print density, Figure 7, when printed on the gloss paper. The largest density differences were measured on the matte and gloss coated samples. The density of the gloss coated sample was greater than the uncoated, while those from the matte coating were lower than the uncoated test strip. The effect on the density caused by the satin coating is variable. The effects of the different coatings on the density vary dependent on the color being coated, yellow being affected the least of all, and followed by the cyan ink. The largest effects were measured with the black, magenta and reflex blue inks. The measured density differences in these cases were approximately 0.20 to 0.25 density units. Comparing two identical prints with this density difference, without coating, would result in a visually unacceptable color difference.

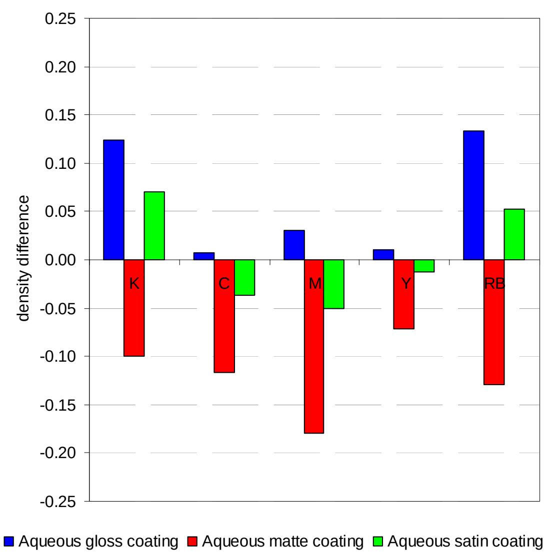


Figure 7: The effect of aqueous inline coating on gloss paper

Evaluation of the influence of coating on matte paper shows that the measured density changes are also affected by the substrate, Figure 8. The same general trends are seen, in that gloss coating increases the measured density, while matte coating reduces the measured density. The magnitudes of these changes were different, as were the relative effects on the different colors. In general, the density of the gloss coated samples increased by 0.05 density units, while for the matte coating only the densities of the black and reflex blue colors increase.

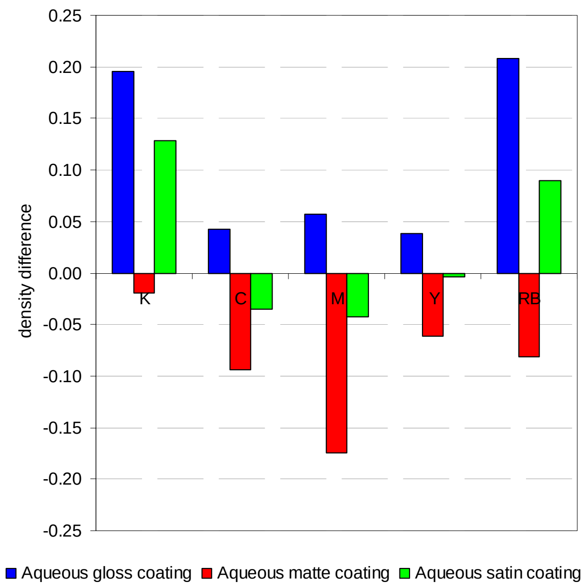


Figure 8: The effect of aqueous inline coating on matte paper

The UV gloss and satin coatings have a minimal effect on the all but the reflex blue, where there was a large increase in the measured density. There was a significant reduction in the measured values with the matte coating except for the yellow ink. The influence of the matte paper, Figure 9, was to minimize the differences seen with the matte coating while increasing the density differences with both the satin and gloss coatings. This resulted in significant density differences being measured for all of the patches, including the yellow. Very large changes were measured on the reflex blue patches, the gloss coating increasing the density differences greater than 0.20 density units.

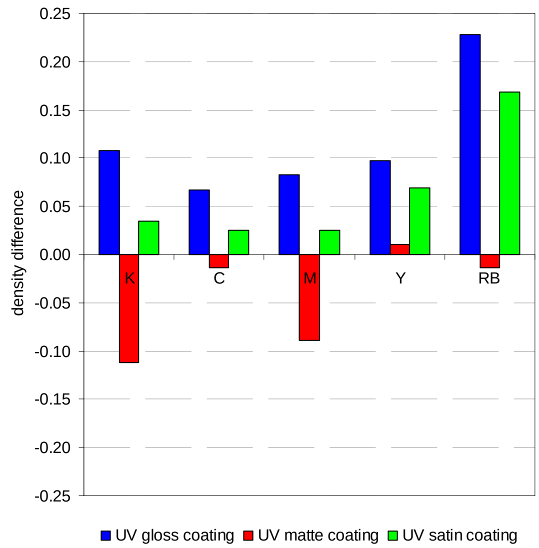


Figure 9: The effect of UV inline coating on matte paper

The effect of coatings on the measured density was significant and would significantly alter the appearance of samples were these patches used for setting the press. This may, in some part, explain why there can often be large color differences that are attributed to the coating, whereas they may well be due to a color shift by printing to different ink densities. The use of an uncoated test strip would allow for accurate control of the process. In addition, were the targets to be adjusted to allow control using the coated test strips, then measured changes could be caused by either alteration in the ink density or changes in the coating film thickness.

The application of the coating will also affect the tone gain that is calculated from the test strip, an example is shown in Figure 10 for the 50% halftone. The tone gain was always higher for the coated samples than the uncoated in all the scenarios investigated. Throughout all the analysis, the matte coating normally produced a slightly lower tone gain, for both the UV and aqueous coatings. The tone gain calculated for the matte paper is higher than that on the gloss paper by approximately one percent. The UV coatings produced a higher tone gain difference, approximately 3.5 / 4 percent higher. These changes were a result of the coating type / thickness and not a wet on wet interaction between the coating and the ink when the prints were produced. The changes are not only due to the solid density changes but also due to the changes to the halftone areas, which at times does not follow those from the solid density.

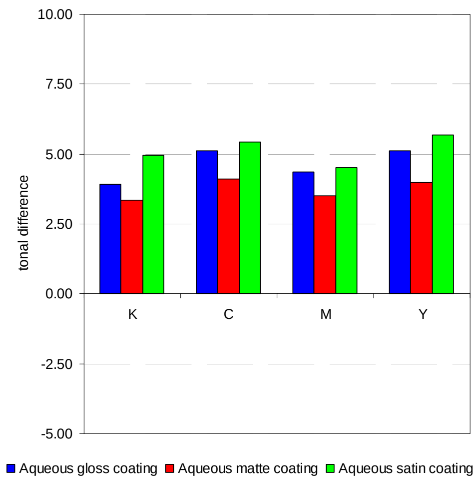


Figure 10: The effect of aqueous coating on tonal reproduction at 25% coverage on gloss paper

Finally, the color differences between the coated and uncoated samples were evaluated. These were calculated directly from the two test strips and were not normalized. The color changes between the coated and uncoated samples are shown in Figure 11 for UV coatings on gloss paper. These also show the difference between the front and back of the sheet (uncoated). These results are different when compared to density variations. The consistency between colors was much lower than with the density differences and the relative effects on the colors is also changed, most notably with the yellow ink where there is a large color shift but there was only a small density difference. Throughout all the results there is a color shift, indicating that the application of the coating is affecting the measurement values obtained.

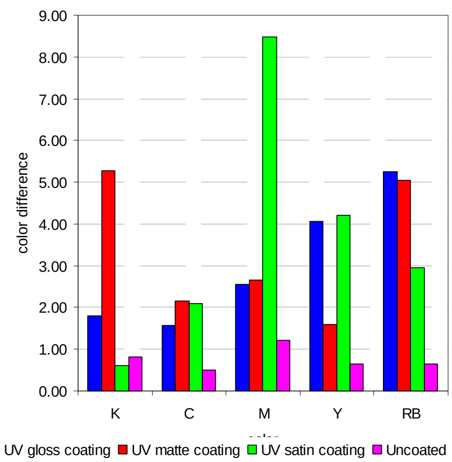


Figure 11: The color change due to UV coating on gloss paper

## Closure

A detailed experimental program has been completed evaluating the effect of coating on the appearance, measured gloss, density and color of the prints. The press conditions were controlled to produce very consistent prints, generally within a mean density tolerance difference less than 0.02 density units. The use of a second test strip on the print form that was not coated allowed the direct comparison within each printed sheet. The results from the analysis can best be summarized as;

- There was very little visual difference between the coated and uncoated samples.
- The application of the coating created a large difference in the measured density, with the matte coating generally reducing the value while the gloss increased it.
- The measured tonal reproduction appeared to increase for all coatings
  - The largest effects were found at the low halftone coverage.
  - The UV coatings affected the measurements more than the aqueous coating
- The measured color of the patch was altered (ΔE value); in the majority of cases this was significant.
- These measurement effects detected were a result of the coating interfering with the measurement geometry.

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