A New Topography Measurement Using Modified Scanner & Results Correlation to Print Mottle

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Abstract

A new instrument for the measurement of surface topography, known as "Verity IA Topography", has been introduced. This instrument objectively quantifies and ranks the surface topography of paper and board and can also quantify the degree of mottle present in printed specimens. This paper describes tests conducted on a variety of substrates that include coated and uncoated printing grade papers and boards. It is shown that the methodology used is applicable to any surface destined to receive a printed image using a contact printing method and may have application to non-contact print.

The instrument's dual capability of measuring both topography and mottle was used to numerically rank the surface topography of a series of Light Weight Coated sheets and to correlate this ranking to print mottle measurement made after the same sheets were printed with a web offset press. In these tests the instrument provided a relative measure of surface topography which correlated very well, $r = 0.89$ to $r = 0.96$, with the relative print mottle measurements. Also presented are data and results from additional tests run to correlate the instrument measurements with expert visual rankings of coated board.

Verity IA Topography can measure the topography in areas as large as 200 mm x 200 mm in one action taking less than 30 seconds and within the same scanned image measure a printed area for mottle. In print trials the instrument software can be configured to scan a large imaged area that can be sub-divided to measure and report the unprinted surface topography separate from the mottle measurement in the printed areas.

These tests demonstrate this instrument can emulate the human in visual printing surface evaluation and holds a great potential to objectively predict the quality of print based upon surface topography measurements.

All of the images shown in this paper come directly from the Verity IA Topography software, or a related application, Verity IA Print Target, without enhancement and are typical of those displayed by instruments using this software.

An Example: Topographic Surface vs. Print Mottle

Shown below in Figure 1 are magnified images of two grades of coated 80# Text. The coatings on these sheets differed, one being a matte finish the other best classified as a semi-gloss. The images in Figure 1 are extractions from the larger images similar to those used to create the data shown in Table 1 and plotted in Chart 1 in the main body of the work. The Verity IA Topography numbers shown under the images are for the small area measured but, as can be observed in the data in the main body of the paper, they can be extrapolated to the larger area.

Unprinted	
Semi- Topo # 2.61	**Matte - Topo # 7.3**

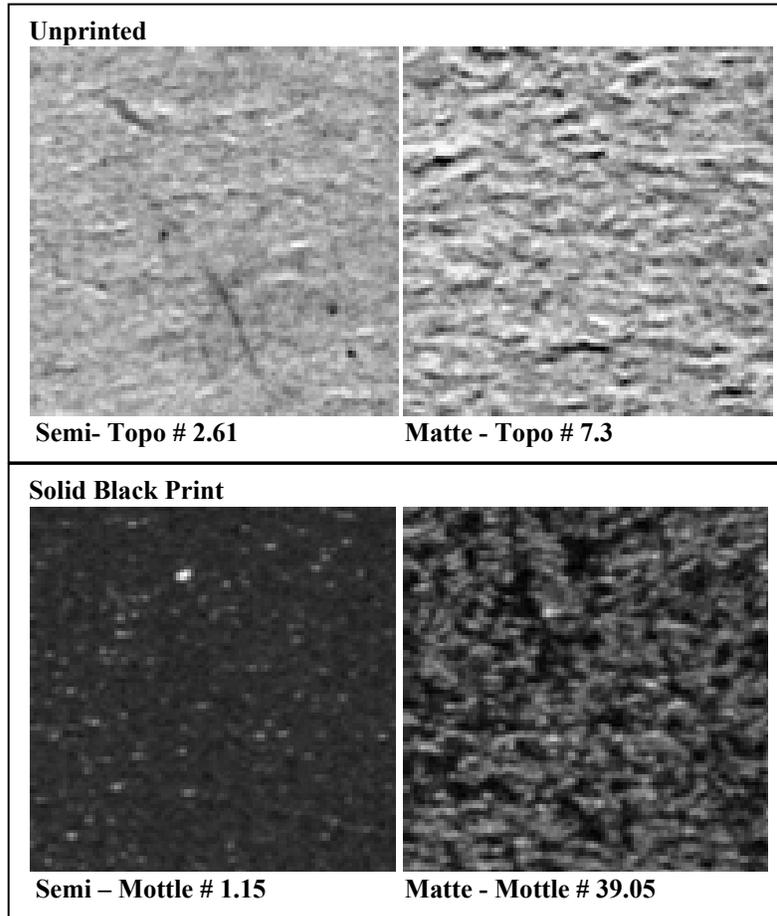| Solid Black Print	
Semi – Mottle # 1.15	**Matte - Mottle # 39.05**

Figure 1: Very small areas of the originals used in the work comparing the topographic measurement of 80# Text, semi & matte finishes, unprinted area of sheet to a solid black print on the same sheet, demonstrating relationship between topographic measurements and visual characteristics.

All images are enhanced to increase detail visibility.
Physical size: 4.2 mm x 4.2 mm: 17.64 sq mm (Normal size used in investigation was between 950 sq mm for the unprinted margin and 3800 sq mm for printed areas.)

The Test Apparatus

The analysis instrument used in the tests is a Verity IA Topography produced by Verity IA LLC. It is a bench mounted unit, familiar in appearance to an image analysis system but using a specially modified graphic arts quality high resolution color scanner called "Verity-Topo™" with a 220 mm X 300 mm bed. The Verity IA Topography software, in combination with the Verity-Topo is able to produce the high definition gray-tone images of the surface topography and print mottle as shown throughout this paper.

The topographic and print mottle measurement algorithms are derivatives of the Verity IA Stochastic Frequency Distribution Analysis (SFDA). This algorithm is currently widely used to evaluate print mottle and paper formation. It presents a single number result that can be scaled to fit the type of surface inspected or image presented for analysis.

Evaluation 1, Light Weight Coated paper printed at RIT:

This evaluation was conducted at the Rochester Institute of Technology under the following conditions and procedure in an effort to discover the level of correlation between printing surface topography and offset print mottle in Light Weight Coated grades of paper.

The Printing Paper

Seven (7) lots of Light Weight Coated (LWC) papers designed for the same end use and having similar or identical weights suitable for offset printing were used. The paper was received from seven (7) undisclosed sources and received as rolls suitable for web press print.

The Print Apparatus

The offset press at the Rochester Institute of Technology was used to print all of the specimens used in this test. Press description:

> Goss Sunday 2000 Web Offset Press
> 6 over 6 perfecting
> Speed 610 meters/min (2000 fpm)
> Basis Weight Range: 20 # to 100# Text
> Web width range: 35.6 cm (14 in) to 145 cm (57 in)
> Roll Diameter range: 35.6 cm (14") to 127 cm (50')

The Print Target

The paper was printed with targets of many different types most of which were designed for subjective evaluation of the paper performance. One section of the print area was reserved for the image analysis target, shown in Fig. 2. This area was not reverse side printed on both the top and the bottom of the web. No matter how the sheet was viewed, from the top or bottom (underside), the print target area was not printed on the other side.
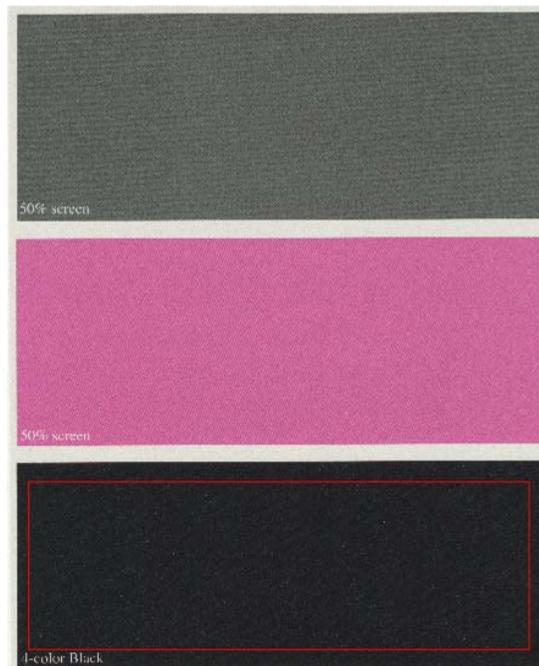

Figure 2: The print target used in the tests. At the top is 50% screen Black. Mid-way is a 50% screen Magenta. At the bottom is a four (4) color Black which was used in the correlation study. All areas are 55 mm x 145 mm. This target was printed on the top and bottom sides of the sheet and arranged in such a way so the opposite side remained unprinted. This prevented any possible "Show Through" effects marring the measurement of the relationship between topography and print mottle.

The red rectangle surrounds the area in which the measurement will be made by the Verity IA system.

Procedure

A slab from across the width of each roll of the seven lots of paper, measuring approximately 30 cm wide and 3 cm deep, was removed and identity marked by lot, roll number as being "Before Press". These specimens were later used for the topographic measurements.

The seven lots of paper we then printed on the Goss press. The same inks and other running conditions were maintained of each lot. At the end of each run specimens from each lot were save for later measurement of print mottle.

Measurements:

Both sides of the papers, top and bottom, before and after printing, were measured using topography and mottle settings in the Verity IA software.

Top Mottle Index — 4 Color Black / Surface Topography Top

#				Average	Stdev	Average	Stdev
1	6.2	6.7	6.1	6.3	0.363	11.6	2.046
2	4.3	3.7	3.9	4.0	0.271	16.1	0.687
3	5.1	5.1	4.8	5.0	0.178	12.9	0.895
4	49.4	48.8	50.5	49.6	0.871	33.0	1.970
3	5.0	5.6	3.9	4.8	0.890	12.9	0.895
4	25.5	30.5	30.3	28.8	2.839	33.0	1.970
7	46.6	42.9	49.4	46.3	3.244	52.1	1.662

Correlation: 0.91

Bottom Mottle Index — 4 Color Black / Surface Topography Bottom

#				Average	Stdev	Average	Stdev
1	8.3	7.8	7.6	7.9	0.349	9.7	1.335
2	12.0	12.8	10.5	11.7	1.170	20.4	1.868
3	8.8	9.1	7.6	8.5	0.757	11.5	0.641
4	55.6	56.5	56.4	56.2	0.524	32.3	1.000
3	7.9	7.4	9.0	8.1	0.839	11.5	0.641
4	46.5	48.8	45.7	47.0	1.582	32.3	1.000
7	52.8	55.2	52.3	53.5	1.534	53.3	2.185

Correlation: 0.89

Top Mottle Index — 50 % Tint Black / Surface Topography Top

#				Average	Stdev	Average	Stdev
1	12.3	12.4	12.9	12.5	0.302	11.6	2.046
2	13.8	13.7	13.9	13.8	0.109	16.1	0.687
3	7.8	7.6	7.5	7.6	0.163	12.9	0.895
4	34.8	34.9	32.6	34.1	1.313	33.0	1.970
3	19.6	18.7	19.6	19.3	0.535	12.9	0.895
4	63.3	65.0	68.0	65.4	2.377	33.0	1.970
7	85.9	78.1	87.7	83.9	5.128	52.1	1.662

Correlation: 0.94

Bottom Mottle Index — 50 % Tint Black / Surface Topography Bottom

#				Average	Stdev	Average	Stdev
1	7.2	7.1	6.8	7.0	0.218	9.7	1.335
2	8.8	8.6	9.4	8.9	0.419	20.4	1.868
3	5.2	5.3	5.0	5.1	0.159	11.5	0.641
4	13.9	13.4	13.1	13.4	0.416	32.3	1.000
3	7.6	7.3	7.6	7.5	0.181	11.5	0.641
4	13.8	14.1	15.0	14.3	0.621	32.3	1.000
7	28.1	30.1	31.2	29.8	1.581	53.3	2.185

Correlation: 0.96

Table 1: Left is Top of sheet; Right is Bottom of sheet. Data from the seven (7) lots of LWC before and after printing are given along with the correlations between topography as measured before printing and the mottle measurements in both the 50% Black and the four (4) color black. There is a better correlation using the 50% black.

The data and the correlation of topography to print mottle for the top and bottom of each lot of paper are presented in Table 1. The print mottle was measured in three sheets from each lot and averaged together. Five sheets from each lot were measured for topography both in the MD and CD and then averaged.

Conclusions:

As shown in Table 1 and Charts 1 & 2 the correlation between topography and mottle using the Verity IA instrument is very good. It should be noted: Two of the seven lots were actually the same paper but labeled differently. This was not disclosed to the evaluators until the data were being tabulated and analyzed. Thus the Data in Table 1 shows only five different lot numbers with two of them repeated (3 & 4).
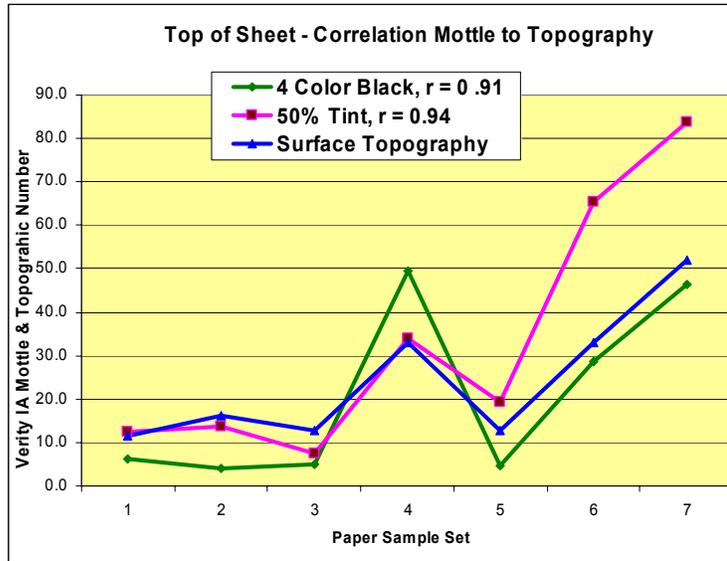
Chart 1: Top side of sheet – Verity IA Mottle Number vs. Sheet Optical Surface Topography Number for four color black and 50 tint black..
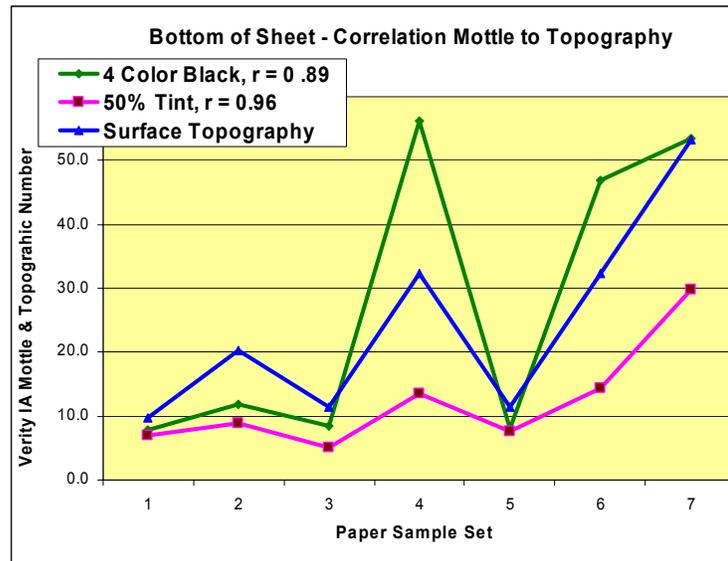

Chart 2: Bottom side of sheet – Verity IA Mottle Number vs. Sheet Optical Surface Topography Number for four color black and 50 tint black..

Evaluation 2, Examination of Coated Board

A set of thirteen (13) white coated bleached kraft board was tested with the topography system. The set had been previously ranked by quality control production personell trained and skilled in the evaluation of the board surface for optmal print quality. The results of the topographic and visual rankings as shown in Table 3, plotted in Chart 3 and example images of the board surface are shown in Fig 3. The correlation of the topographic measurement as an average of the MD and CD to the visual evaluation is 0.87.
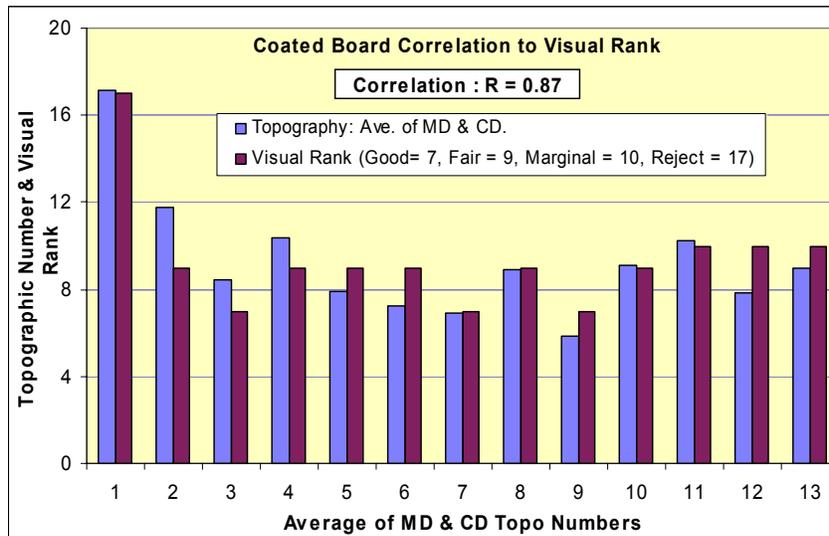

Chart 3: Comparing the visual ranking to the measurements of topography indicated a very high correlation of R = 0.87, very good for subjective to objective comparisons. The topo results are the average of the MD and CD measurements given in Table 3.

Coated Board, Reel #18 Machine Direction

| Front – Topo # 12.4 | Mid - Topo # 8.1 | Back – Topo #11.2 |

Coated Board, Reel #18 Cross Direction

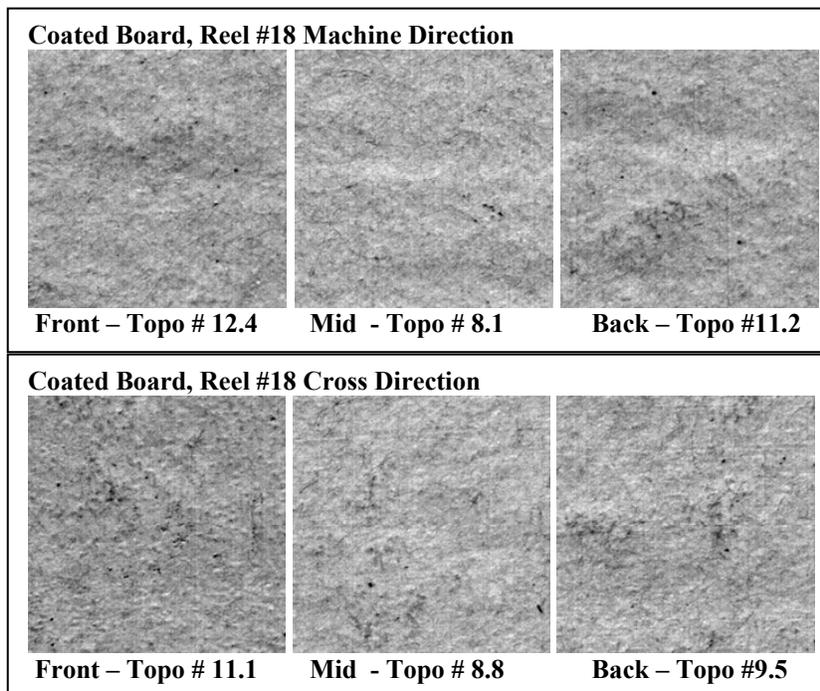| Front – Topo # 11.1 | Mid - Topo # 8.8 | Back – Topo #9.5 |

Figure 3: Coated white bleached kraft MD & CD images taken at three positions across the machine. The images visually capture the subtle differences measured by topography.

Reel Position	Expert Ranking	Measurement Direct	Topo #	Average Topo #
Base Line				
Back	17, Reject	1MD	15.5	**17.15**
		1CD	18.8	
Reel #18				
Front	9, Fair	3MD	12.4	**11.75**
		3CD	11.1	
Mid	7, Good	4MD	8.1	**8.45**
		4CD	8.8	
Back	9, Fair	5MD	11.2	**10.35**
		5CD	9.5	
Reel #4				
Front	9, Fair	6MD	6.9	**7.9**
		6CD	8.9	
Mid	9, Fair	7MD	7.3	**7.25**
		7CD	7.2	
Back	7, Good	8MD	5.6	**6.9**
		8CD	8.2	
Reel #12				
Front	9, Fair	9MD	9.9	**8.9**
		9CD	7.9	
Mid	7, Good	10MD	6.7	**5.85**
		10CD	5	
Back	9, Fair	11MD	10	**9.1**
		11CD	8.2	
Reel #16				
Front	10, Marginal	12MD	9	**10.2**
		12CD	11.4	
Mid	10, Marginal	13MD	7.6	**7.85**
		13CD	8.1	
Back	10, Marginal	14MD	9.1	**8.95**
		14CD	8.8	

Table 3: A set of specimens taken from three positions arranged across the reel, front, mid and back, of coated white bleached kraft were tested using the topography instrument. The specimens were 300 cm square and the sampling area was 150 mm x 100 mm. The specimens were uniformly rotated 90° and retested. The results of the two tests were averaged and correlated to the visual evaluation of the surface as shown in Chart 3, with a correlation of R: 0.87.

Conclusion

This series of tests has demonstrated that within the product and grade groups examined, the Verity IA instrument produces measurements that show a direct relationship exists between the topography measurement made in a large area of the substrate and the print mottle measurement made on the same specimens. In addition the instrument can emulate the subjective ranking of the coating surface on white bleached kraft board.