

Effect of Substrate Topography on Print Quality in Gravure Press

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ABSTRACT: Gravure printing is regarded as the prominent printing process amongst the conventional which delivers high print quality. Moreover, gravure print quality is subjective and greatly dependent on substrate surface i.e. topography. Topography of the paper substrate plays a significant role in the dot reproduction on substrate. The surface undulation creates often problems such as missing dots and denigrates the print quality. Also, the print attributes such as density, dot gain are more influenced by the topography. Thus, this paper studies the effect of topography on dot reproduction fidelity. For investigation three paper substrates were chosen viz. two coated stock and one uncoated stock; denoted as grade A, B and C respectively. The topography of the substrate was evaluated using Verity IA print target software. The substrate surface was scanned at 1200 ppi using Epson V700 scanner. The printability on these substrates was gauged by density, dot area, missing dot and print mottle. The results revealed that, paper grade A surface with lower topographical index showed less missing dots, lower print mottle, dot area and higher density. Higher topographical index was seen in paper grade C which showed distorted dot reproduction thereby reduced the print quality.

KEYWORDS: Topography, Density, Missing dots, Dot area and Print Mottle.

I. INTRODUCTION

Roto-gravure is best known for its high quality and long run jobs amongst the conventional printing processes. Amongst all the printing process gravure printing delivers more consistent throughput. However, gravure print quality is mostly affected by the surface properties of substrate surface [1]. Therefore the gravure press needs to be adapted to each substrate for consistent print quality. The transfer of ink on substrate surface depends predominantly on the surface properties of the paper. Topography of the substrate is the most significant factor which affects ink transfer from cells due to undulations, pits and pores. These irregularities denigrate the print quality. Hence, quantification and characterization of the paper substrate's surface is important for predicting the ink lay down on the paper surface [2, 3]. Thus the main goal of this paper was to do quantitative analysis of topography and its effect on print quality in gravure printing process.

II. RELATED WORKS

Rosenberger, R and Clark, D conducted a study on the measurement of topography with a modified scanner and correlated topography with print mottle. The experiment was conducted on two different paper grades i.e. coated and uncoated. Test specimens were printed on Goss Sunday 2000 Web Fed Offset press. For the analysis of topography and print mottle, images were scanned by Verity-Topo scanner at high resolution and were measured using Verity IA Print Target software. The results of surface topography were correlated to print mottle; additional test runs were conducted to correlate instrument measurement with visual ranking. Topography was measured on both side of the paper before printing. To measure print mottle different patterns were printed on paper (i.e. 50% black, 50% magenta, 4-color black) in the area of 55mm X 145mm. The correlation between surface topography and print mottle was found having $r = 0.89$ to $r = 0.96$. Also significant correlation between instrument measurement and visual ranking was found with $R = 0.87$.

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From the study researchers concluded that Verity IA Print Target software could emulate the human in visual print mottle evaluation, the research predicted that the quality of print was based upon surface topography measurement.

Velho.J and Santos.N conducted the experiments to study the effect of surface topography of coated paper and print quality. For the experiment, researchers considered commercial printing papers (100 GSM) coated with two different calcium carbonate composition one with calcinitic natured scalenohedral particle shape (CC-S) and the other argonitic natured acicular particles (CC-A) with a coat weight varying in the range of 2.5 g/m² to 3.5 g/m². Coating color was prepared by using carboxylated styrene-butadiene latex as a binding agent. Two different carboxymethyl cellulose were used i.e. C35 (MW=35,000 g/mol) and C250 (MW=250,000 g/mol) as rheological modifiers. Surface topography was measured using laser and mechanical profilometry whereas the substrate was scanned by electron microscope. Surface energy of substrate was determined by Owens Wendt RabelKaelble (OWRK) method by using contact angle measurement. Surface tension of ink was measured by Pendant Drop method. Print quality was determined by analyzing print mottle, dot gain, and optical density. Inkjet printing method was used for printing the samples. Specific masking was done for each color (black, cyan, magenta, yellow, green, blue and red) to determine the inkjet print quality. The black area was analyzed for mottle analysis; images were scanned by using microtek-scan-maker 8700 scanner. It was observed that in CC-A substrate macro roughness was higher while micro roughness was lower when compared to CC-S substrate. Higher rheo-thickening was observed on CC-S with C-35 than C-250. According to the results CC-A substrate had lower optical density due to high surface roughness and lower surface energy as compared to CC-S. Lower surface energy was observed because CC-A had more polar components. Print mottle was found to be lower with C-250 because it exhibited high optical density than C-35. CC-A substrate showed less dot gain compared to CC-S because it had more valleys and it led to ink penetration than ink spreading. The research concluded that optical density and print mottle improved with the use of rheo-thinning suspension.

III. METHODOLOGY

Topography Analysis

Three different substrates two coated and one uncoated stock were chosen for topographical analysis of the experiments. The substrates were denominated as A, B and C respectively. The topography of the substrates was evaluated with Verity IA Print Target software [4].

Verity IA Print Target software allows us to view area of interest (AOI), under magnification which facilitates us to visually identify the problem causing elements on the substrate surface [5]. The software also selects the background color using a color extraction algorithm to make the aberrant elements easily distinguishable using a false color view mode.

The unprinted rolls were cut to sheet and forwarded to topography analysis. The samples were scanned using Epson V700 scanner at 1200 dpi. The topography was analyzed at an AOI (Area of interest) of 70 X 55 mm.

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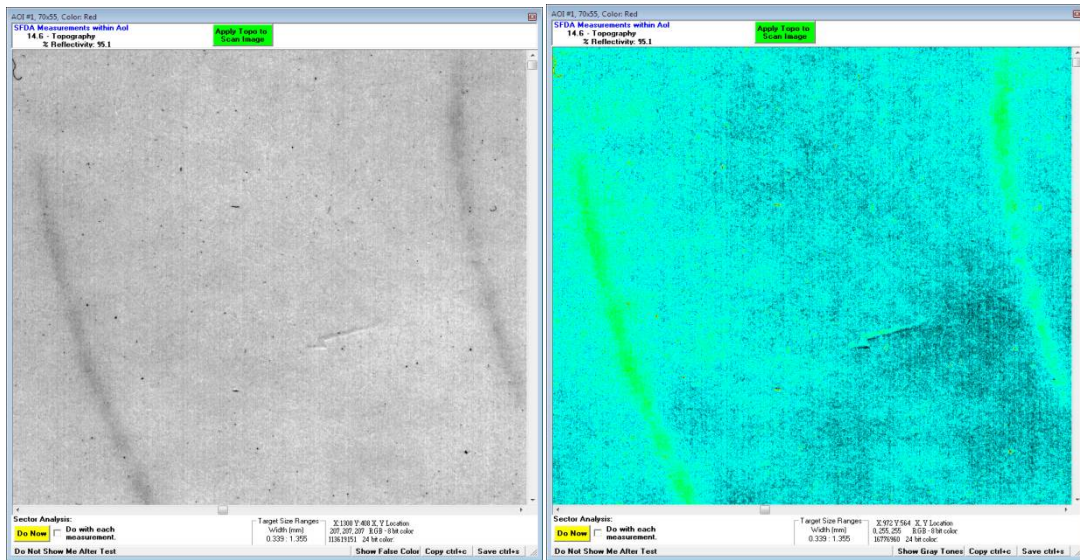


Fig. No. I Topography measurement using Verity IA Imaging Software

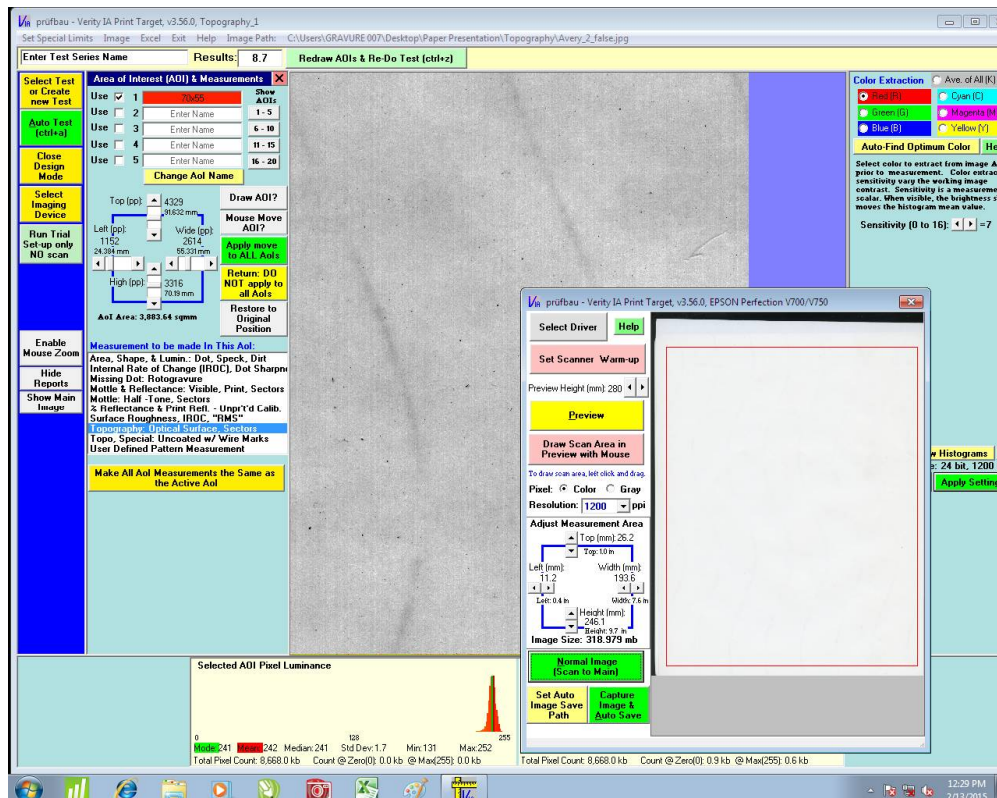


Fig. No. II Topography analysis

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Table No. I Topography of Unprinted Stock

Sample No.	Substrate A	Substrate B	Substrate C
1	7.74	91.94	442.8
2	8.68	85.40	480.5
3	12.04	86.96	470.8
4	12.80	94.58	481.3
5	12.36	87.86	490.2
Mean	10.72	89.35	473.1
Standard Deviation	2.335	3.795	18.288

The topography of coated substrate A showed a lower topographical index followed by grade B and C. The paper grade C resulted higher topography due to more undulations.

Printing:

The samples were printed on roto-gravure machine with black ink. The machine presetting are as followed.

❖ Presetting Parameters:

- Acrylic based ink
- Viscosity of ink – 19 sec on B4-ford cup
- Speed of machine – 120 m/min
- Hardness of Impression roller – 80 Shore A
- Impression Pressure – 3.5 kg/cm²
- Web Tension – 5 unit
- Dryer Temperature –60⁰C

IV. RESULTS

The printed stock were cut into sheets and forwarded for printability analysis; the parameters considered are as stated below:

- Density
- Dot Area
- Print Mottle
- Missing dots

Density analysis:

Density is defined as log of opacity. It is the light blocking ability of a substrate. The density of the printed sample was measured at solid patch using eye-one pro spectrophotometer.

Table No. IIDensity of Solid Patch on Printed Stock

Sample No.	Substrate A	Substrate B	Substrate C
1	2.10	2.09	1.20
2	2.11	2.09	1.20
3	2.09	2.00	1.21
4	2.10	2.13	1.19
5	2.12	2.11	1.23
Average	2.104	2.084	1.206
Standard Deviation	0.011	0.050	0.015

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The higher the print density better is the print contrast. By analyzing the above results the best print density of a solid patch is obtained in coated grade A followed by B and then by grade C. The absorption and spreading of the ink on the uncoated stock 'C' has resulted in lower density value.

Dot Area analysis:

The dot area was analyzed at 50% step wedge. The area covered by dot depends upon substrate's surface characteristics and press parameters.

Table No. III Dot area at 50% dot

Sample No.	Substrate A	Substrate B	Substrate C
1	61	72	77
2	61	72	78
3	62	71	75
4	60	70	76
5	61	72	77
Average	61	71.4	76.6
Standard Deviation	0.707	1.483	0.894

The dot area covered by 50% dot is highest in case of grade C, followed by B and A. The fibers of the uncoated stock being unorganized and unsized absorb ink and spread it on the surface of the substrate. With this it is evident that the substrate is also responsible for the dot gain in the press. The substrate with higher topographic index showed higher dot area.

Missing Dots:

The dots that are not reproduced on the substrate are called as missing dots. Their frequencies were analyzed by missing dot analyzer. It has been a common observation that as dot size reduces the number of missing dots increases.

Table No. IV Missing Dots at 30% dot

Sample No.	Substrate A	Substrate B	Substrate C
1	0	268	Cannot be determined
2	0	246	
3	0	213	
4	0	236	
5	0	279	
Average	0	248.4	
Standard Deviation	0	26.140	

The number of missing dots were observed more in grade B followed by grade A. In grade C, it is very difficult to identify dot due uneven spreading of ink on the substrate.

Print Mottle Analysis:

Print mottle is the measure of unevenness in the density of the printed sample. It is also the visual irregularity in the printed area. The solid patches were scanned by Epson V700 scanner and analyzed for print mottle by Verity IA print target software having an AOI of 70 X 55mm.

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Table No. VPrint Mottle Measurement on a Solid Patch

Sample No.	Substrate A	Substrate B	Substrate C
1	1.3	4.8	45.3
2	1.4	3.7	46.9
3	1.19	4.2	46.4
4	1.34	4.5	53.8
5	1.2	4.1	42.6
Average	1.286	4.26	47
Standard Deviation	0.090	0.416	4.149

The print mottle is higher in the grade C due to the presence of loose fibers on the surface of the uncoated paper absorbs ink and spread it in an uneven manner. Thus the higher topographic index results in higher mottle.

V. CONCLUSION

The experimental investigation on three substrates showed varying topographical index. The printability on these substrates was analyzed by density, dot area, missing dots and print mottle.

Thus the result highlighted that as topographic index decreased the density increased and the dot area decreased due to lower spreading of the ink.

The trends also concluded that lower the topographical index i.e. lower undulations in the substrates resulted in lower print mottle and lower missing dots.

REFERENCES

1. Gandhi. V, Kumar. R, "Effect of Nip Pressure Parameters on Substrate's Surface Characteristic and Printability in Roto-Gravure Printing", Article published in *Imprint*(2014).
2. Cruz M. A. Joyace M., Fleming, P. D. and Rosenberger, R. "Comparative study: Verity IA Topography", Emveco, and Parker Print Surf.
3. Johansson P.A, "Optical Homogeneity of Prints", (1999).
4. Rosenberger. R and Clark. D "A new topography measurement using modified scanner & results correlation to print mottle". Verity IA, Appleton WI 54914.
5. Velho. J and Santos. N. (2010) "Surface topography of coated papers: from the evaluation process to the quality improvement". *Trans Tech Publications*, Vol (636-637),pp. (977-984).