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Effect of NIP Pressure Parameters on Substrate's Surface Characteristics and Printability in Roto-Gravure Printing

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Abstract**—***Packaging and specialty print industry is experiencing an exponential growth in terms of customer demands. Surface characteristics of the printing substrate have an indubitable effect on print quality. Porous substrates inherently possess a surface structure in the form of peaks and valleys which can be characterized by properties such as topography and formation. Roto-gravure printing is considered a pioneer in high quality long-run jobs, especially for printing packaging materials. The printing process employs heavy nip pressure to draw the ink out of recess cells engraved on the gravure cylinder. Moreover, impression cylinder of different hardness can be used while printing, which in turn affects the net force acting at the nip. Such high pressure reflects substantially on the surface features of substrate in terms of smoothness and texture. This study aims at determining and quantifying the effect of printing pressure and impression roller hardness on nature and extent of changes occurring at the substrate surface and their corresponding influence on the print quality. Printability can by fairly gauged by studying densitometry and print defects. Hence, density, dot gain, missing dots and print mottle were used as measures of printability. Surface topography was found to reduce with increase in nip pressure. Although, slight decrease in density and increase in dot gain was observed at higher effective nip pressure, lesser missing dots and print mottle were obtained at higher hardness and pressure. Hence, it was concluded that higher effective nip pressure tends to minimize the amplitude and frequency of above-mentioned print defects, thereby reflecting positively on printability.*

Keywords:**—***Impression roller hardness, impression pressure, topography, printability*

1. INTRODUCTION

Gravure print quality is mostly affected by the surface properties unlike the other printing processes. Therefore the gravure press needs to be adapted to each substrate for consistent print quality. While standardizing the press the substrate parameters are not taken into consideration; only few, however surface topography and roughness hasn't been considered as a major factor in improving the print quality. This study shows Topography and roughness have significant impact on the final print quality. Topography can be defined as the physical or natural features of an object or entity and their structural relationships. Topography and roughness plays an undeniable effect on the printability of substrate. An uneven substrate tends to cause problems on the press. On the other hand, a smoother substrate is expected to show better print results, specially in terms of printability.

Topography and roughness analysis of coated paper substrate was done on unprinted samples in two ways. First the samples measured for topography and roughness value and were again measured by passing through the varying nip pressure. The Coated paper substrate was printed at different levels of nip parameters and then Print mottle, density, missing dots and dot area was analyzed to determine the best print results.

2. METHODOLOGY

Sample Selection:

A representative sample sheet of size of 75mm X 50mm was cut from each roll before printing it on a Roto-gravure machine. Area of interest was kept same for all measurement.

Capturing of Samples:

The Printed and Unprinted samples were scanned using a reflectivity dual lens scanner for image capturing at 600 dpi and 1200 dpi respectively.

Precautions:

Make sure that the scanner bed and substrate are clean from ant foreign contamination as even the minute particle can cause variation in the measured Topography, Roughness and Print mottle.

Processing of AOIs:

The samples were analyzed through the combination of Verity IP print Target V3 software and Epson V700 scanner.

It is possible to view AOI(Area Of Interest) under magnification. This facilitates us to visually identify the problem causing elements on the substrate surface.

After analysis of the Surface Topography, Roughness, The Printability was measured by following factors:

- Density
- Dot Area
- Print Mottle
- Missing dots

Also the software selects the background color using a color extraction algorithm to make the aberrant elements easily distinguishable.

Printability is a relative term. Experts from different sectors have their own way of looking at it. However, Printability can be defined as the print quality achieved by the interaction between ink, paper and process parameters. Gravure is one of the widely used processes for printing labels, the reason being its consistency for longer runs. However, Printing on this comes with challenges. The unevenness in surface of the substrate leads to varying ink lay down on substrate. The imperfection on this substrate cannot be completely eliminated. Furthermore, a printer trying to control factors like cylinder, substrate and ink on the press to eliminate print defects is more or less a paradox.

Printing Process Employed

- Roto Gravure Printing process
- All samples in single colour
- Viscosity of ink 17 sec B4-ford cup
- Speed of machine-100 meters per minute
- Hardness of Impression roller-60 and 80 shoreA
- Impression Pressure-3 and 4 kg/cm2.
- Temperature:25oC and humidity 70%

3. TOPOGRAPHY AND ROUGHNESS ANALYSIS

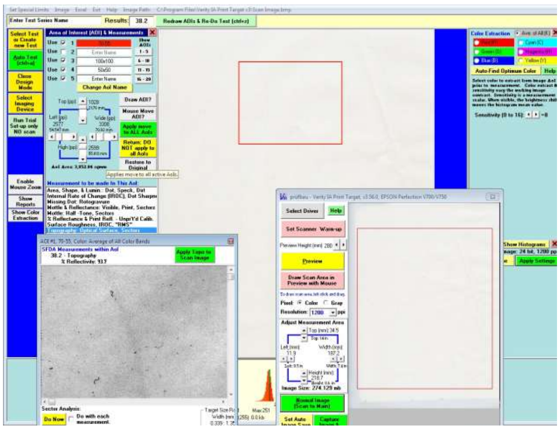

Figure 1: Topography and Roughness

Experimental Data:

Table 1. Before Nip: Topography and Roughness:

Sample	Topography	Roughness
1	16.08	1.348
2	18.16	1.64
3	13.72	1.292
4	15.74	1.454
5	16.6	1.76
Avg.	**16.06**	**1.5**

Table 2. After Nip: Topography and Roughness:

Trial	Topogra-phy	% Re-duction	Rough-ness	% Rise
3-60	14.51	10	1.55	3
4-60	13.91	13	1.62	8
3-80	14.13	12	1.54	3
4-80	12.51	22	1.57	5

Print mottle Analysis:

This figure shows the mottle measurement profile of verity IA Print Target software. 2.The solid patches were scanned at 600 ppi and AOI was kept 70mm X 55mm constant for all measurement.

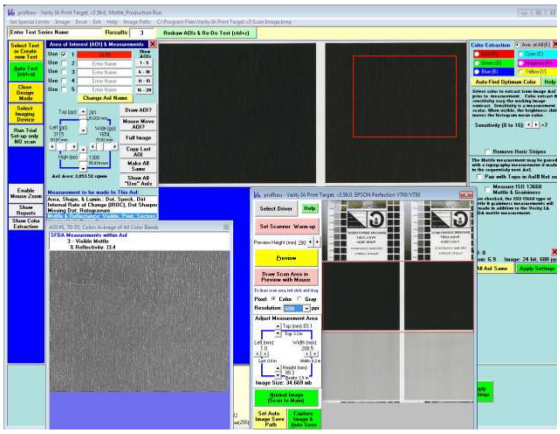

Figure 2: Print mottle

- This is the screen shot of missing dot analysis software.
- The view is at 100 x magnification.
- The red circles represent the missing dots.

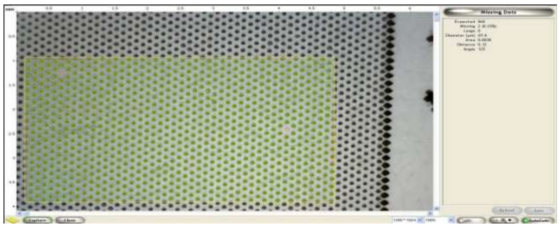

Figure 3: Missing Dot

Table 3 Printability:

Trial	Density (100%)	Dot Gain (Max)	Missing Dots	Mottle
3-60	2.046	8.8	41	4.13
4-60	2.093	13.4	11	2.87
3-80	2.021	11.7	14	3.85
4-80	1.998	14.3	2	2.27

4. RESULTS AND DISCUSSION

The performance of substrate under examination in terms of Topography is of following order:

4-80<3-80<4-60<3-60

A lower value of surface topography corresponds to a smoother substrate. As can be seen from the above results tables pressure 4 kg/cm2 and hardness 60 gives lower topography values. This is due to the fact that at higher pressure and hardness tends to even out the substrate's surface.

While the roughness there was a slight increase in value as the pressure increases this might be due to the fact that the fiber-fiber bond have broken and which causes its roughness value to increase.

Thus, Higher pressure and higher hardness results positively on topography. Roughness was slight to increase when subjected to nip.

For printability, Density increased slightly at higher pressure and decreased at higher hardness.

1. Dot gain was found to increase with increase in pressure and hardness
2. Dot Skips reduced with higher pressure and higher hardness Mottle decreased with increase in pressure and higher hardness.

5. CONCLUSIONS

- Surface topography was found to improve at higher effective nip pressure
- Densitometry responses exhibited slight changes
- Print defects i.e. Mottle and Missing Dots were found to reduce at higher effective nip pressure.

Hence, higher printing pressure and higher impression roller hardness result in higher printability.

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