Comparative Study: Verity IA Topography, Emveco, and Parker Print Surf

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Abstract
Three instruments designed for the measurement of base sheet smoothness, roughness, and topography were evaluated in their ability to predict the surface characteristics of the same base sheet when coated using air-knife and blade techniques and subsequent calendering. To control data point matching the base sheet was marked, and measured in thirty measurement areas, before coating and measured again in the same areas after coating, and again after calendering. Data presented demonstrates correlation of the instruments and results as a process quality control to predict subsequent performance on coater and calendering at 600 pli and 1200 pli.

Introduction
Surface characteristics of paper play a vitally important role in controlling paper and printing quality. Today's paper products must be designed with optimum surface properties to meet increasingly strict performance criteria in a rapidly changing market.

Materials with an atomically flat surface are useful to scientists and industrialist for certain technological applications; however, the majority of materials have an irregular surface, made up of undulations and even perhaps steep gradients and pores. These constitute the topography of the surface, a property that is usually difficult to define but can have a considerable impact on a material's performance. Such importance reflects the surface specific nature of many properties: the ability to adhere to another material (coating, ink, etc), optical properties, etc.

In the paper and printing industries, it is essential to measure surface roughness, due to its effect on the achievable print quality. The standard methods use air leakage from a pressurized cylinder, held against the substrate surface, as a roughness measure[1], but a more detailed characterization of the surface is desirable. Existing methods for detailed topography measurement are usually based on comparatively slow point scanning systems[2].

The topography of a particular surface can be measured using profilometry. This is a technique in which a probe is passed across the surface, following its contours, and the height of the probe at any particular point is recorded. The stylus instruments are quite adequate for hard, smooth surfaces, offering excellent accuracy. However, in the case of polymers, the stylus digs into the surface and the results do not truly represent the topography. "Other possible criticisms of stylus instruments for surface profiling include their sensitivity to microphonics and vibrations, particularly during long measurement times, uncertainly in point of contact of stylus on rough surface, and the delicate nature of their stylus and mechanism"[2]. The size of the probe will determine the size of the surface features that may be distinguished, and for smaller scale analysis, atomic force microscopy (AFM) may be used[3]. AFM works by bringing a cantilever tip in contact with the surface to be imaged. An ionic repulsive force from the surface applied to the tip bends the cantilever upwards. The amount of bending, measured by a laser spot reflected on to a split photo detector, can be used to calculate the force. By keeping the force constant while scanning the tip across the surface, the vertical movement of the tip follows the surface profile and is recorded

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as the surface topography by the AFM. The problem with AFM is its small sampling area which may not representative of the sample as a whole.

The Emveco stylus profilometer is one standard device used by the paper industry to measure roughness.[3] It consists of a fine cone-shaped stylus with a radius of 0.001 inch and can be programmed to scan surfaces of various lengths at different point-to-point length scales.

The Parker Print Surf (PPS) is an air leakage test, designed to accurately measure the surface roughness of materials under conditions similar to those experienced during the printing process. The sample is clamped between a measuring head and a specifically designed backing assembly[1,4]. The pressure drop across the surface of the paper is converted into a length scale unit representing the micro-deviations across the surface of the sheet.[5]

The Verity-Topo® is a topography software system used to numerically rank surface topography[6]. The surface of uncoated and coated sheet, web and board, as well as linerboard can be measured using a system composed of a computer, a specially modified graphics quality scanner, and Verity-Topo analysis software[6]. The imaging system is a line-scan camera and illumination apparatus designed to produce large images for analysis, typically 15 cm * 15 cm. The entire image area is analyzed presenting a number that represents not just the small area typical of other roughness, profilers, and printability instruments, but one that is truly representative of the entire surface.

Experimental

The main objective of this investigation was the comparison of a new Verity Topography measurement device to multiple surface topography devices. The effect of coat weight, coating applicator and calendering was studied. The surface topography of the SBS board was first scanned using the Verity system. Using a rewinder the board was unwound to enable thirty, 10 cm * 10 cm areas for each coating condition to be scanned and marked on the backside, Figure 1. This resulted in there being 30 scanned areas obtained for each coat weight and application method. Each scanned area was divided into 9 sections, Figure 2, which were measured with each device before coating.

A commercial coating formulation was applied to the SBS board using the coating pilot facilities at Western Michigan University. The coatings were applied using a roll applicator and metered using both an air knife and blade coater. Preliminary trials were run on a roll of un-scanned board to establish the blade run-ins and air knife pressures that would be required to obtain similar coat weights without adjusting the coating formulation. Once the conditions were established, the coatings were applied to the scanned board at 122 mpm and hot air dried. The coatings applied were prepared according to the formulation given in Table 1.

Figure 1. Scanning of Samples

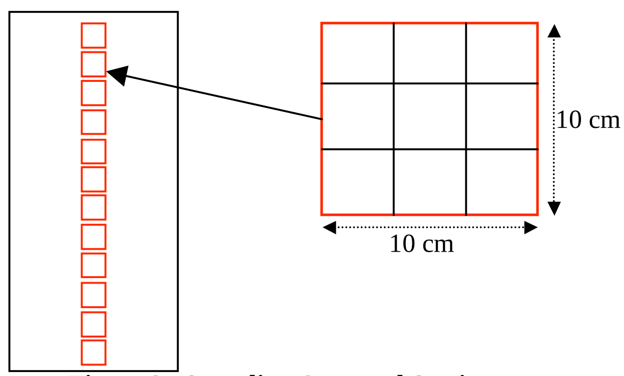

Figure 2. Sampling Area and Sections

Ingredients	Parts
Engelhard, Ultrawhite 90	50
Omya, Hydrocarb 90	50
Dow, PB6620	16
Alco Gum 265	0.05
Ciba, Dispex	0.25

Table 1. Coating Formulation

Three different coat weights, Table 2, were applied for each method; high, medium and low.

The samples were then cut and measured. After being coated the samples were calendered on a sheet fed soft nip calender at two different calendering pressures and again measured.

Air Knife		Blade	
Coat Weight (g/m^2)	Calendering (pli)	Coat Weight (g/m^2)	Calendering (pli)
10.86	600 psi	9.61	600 psi
14.42	1200 psi	13.87	1200 psi
23.92	Non calendered	22.54	Non calendered

Table 2. Coating and Calendering Conditions

An Emveco Stylus Profilometer model 210 was used. The profilometer was preloaded with a fine cone-shaped stylus with a radius of 25 µm (.001 inch). The test conditions were 500 reading per section per 10 cm* 10 cm sample, 0.1 mm space between readings, and 0.5 mm/sec of scanning speed. The roughness R was calculated using the equation:

$$R = 1/N\sum |Z_{i+1} - Z_i| \qquad (1),$$

where Z is the vertical position of the stylus and N=499.

The top surfaces of uncoated, coated and calendered samples were measured using Verity software version V2.8.4. All scans were performed at a resolution of 600 ppi. The Verity software analyzed the surface, producing a number representing the topography of the entire surface. The higher the number, the less uniform the surface. The samples were all scanned in the same sections and areas for the multiple conditions along the machine direction (MD) of the web.

The PPS roughness values were obtained clamping the samples between a head and a specifically designed baking. The measurement area used was 10 cm^2 and a clamping pressure of 1000 kPa.

Results and Discussion

The results are presented to study the ability of the measurement devices to detect differences in surface topography and roughness due to differences in coat weight and application methods used. To enable a direct comparison of the values obtained for each of the measurement devices, the % change in measured value, MV, from the reference uncoated board (2) was calculated and these values compared.

$$\frac{\text{(MV uncoated board – MV treated board)}}{\text{MV of uncoated board}} \times 100\% \qquad (2)$$

The Figures 3 and 4 compare the topography values for the 22-23 gsm, blade and air knife coated samples. For both the air knife and the blade, the results for the Emveco profilometer were higher for the calendered samples. The PPS values were highest for the coated, uncalendered board (condition 2). The values for the Verity Topo were found to be lower, for all the conditions.

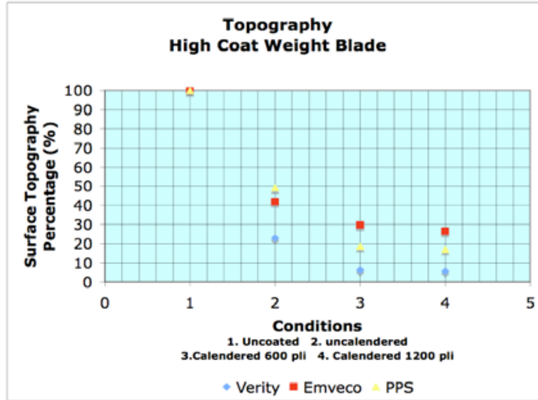

Figure 3. Topography- Blade

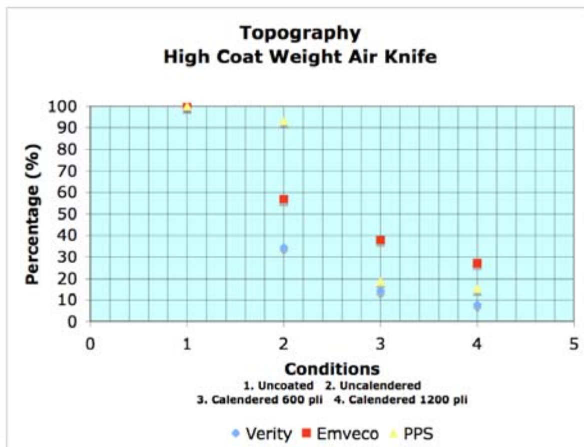

Figure 4. Topography-Air Knife

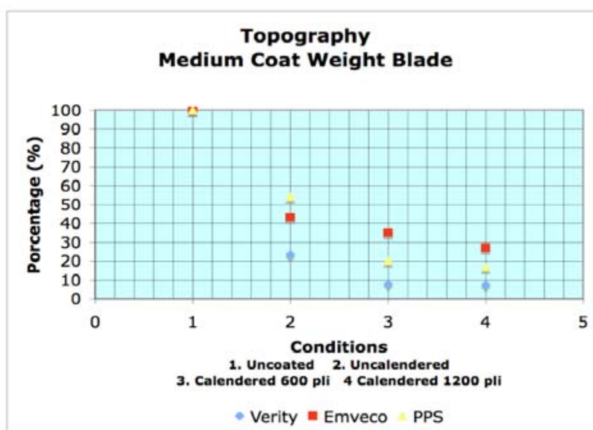

Figure 5. Topography Blade

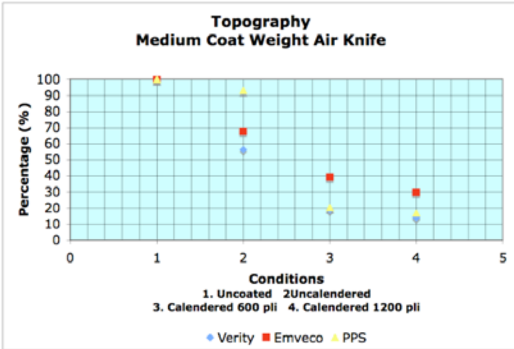

Figure 6. Topography Air Knife

The results for the samples with a coat weight of 14-15 gsm (Figures 5 and 6) show a similar trend to that of the 22-23 gsm samples, but the values are lower due to better coverage at the higher coat weight.

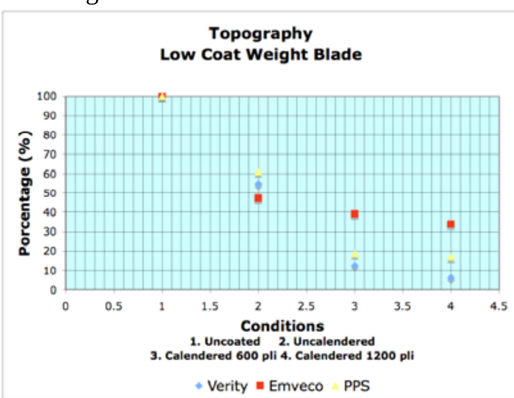

Figure 7. Topography Blade

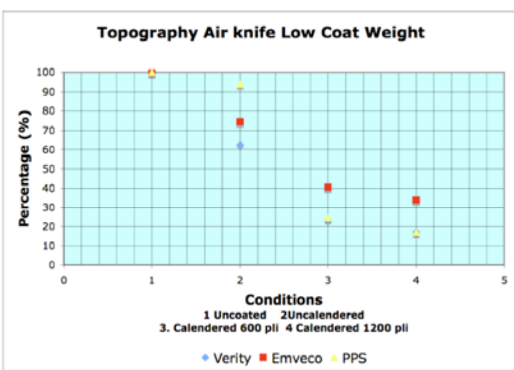

Figure 8. Topography Air Knife

Comparison of the three topography devices for the 9-10 gsm coated samples, Figures 7 and 8, show lower percentage values for the Verity Topo at all the conditions. The Emveco values were highest for the calendered samples. The PPS values fell between the Verity and Emveco values for condition 3 and 4, but were higher for condition 2, which was the roughest sample.

A comparison of the three test methods are presented in Figures 9, 10, and 11. A good correlation was obtained between the Verity and Emveco instruments (r^2= 0.869). A lower correlation was obtained between the Verity and PPS (r^2 = 0.747). It is important to note that the Emveco values were 1 order of magnitude larger than the PPS.

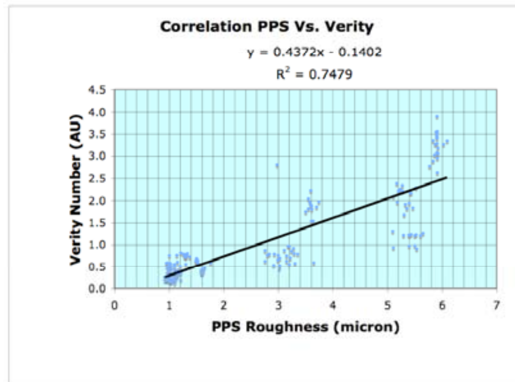

Figure 9. Correlation PPS vs. Verity

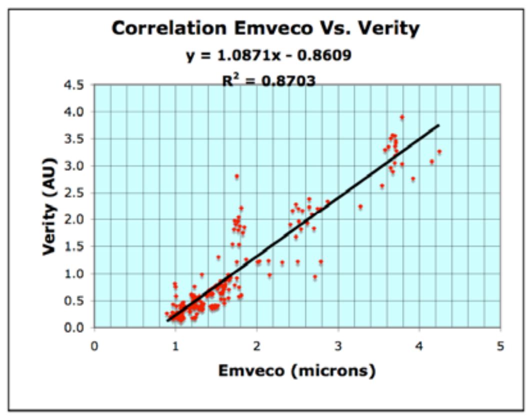

Figure 10. Correlation Emveco Vs. Verity

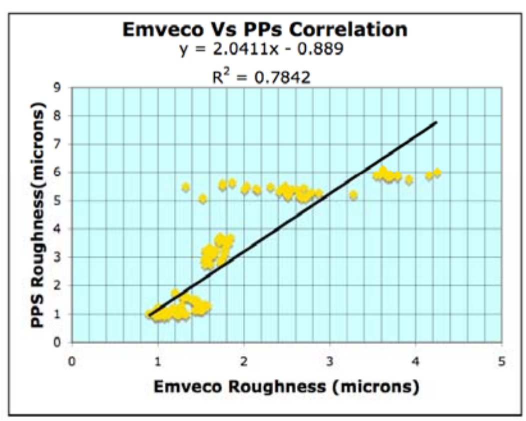

Figure 11. Correlation Emveco Vs. PPS

The Verity Software was able to capture a visual difference between the samples that was not possible to detect using the other two devices. Figure 12 shows the visual differences between one sample at three different conditions, uncoated, coated and coated-calendered. The ability to visually compare samples is unique and important in that the contribution of the base sheet layer to coating appearance may be detectable.

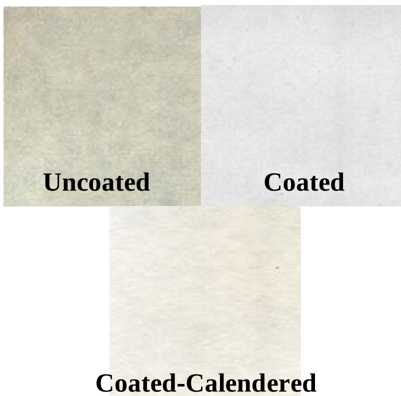

Figure 12: Verity Visual Difference

Conclusions

In this project, SBS board was coated using two different coating devices, three coat weights, and two calendering pressures. A comparison of three different measurement values showed the the correlation between the Emveco Stylus Profilometer and the Verity to better than with the Parker Print Surf.

The ability to visually compare image files as well as topography numbers is a benefit to the Verity System. Also the measured area used for it is more representative in comparison to the other two devices.

References

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