Imaging Reflectometer Applications Data AN1

Measuring calendered papers with the Surfoptic Imaging Reflectometer System

N J Elton

Introduction
This note describes the use of the prototype Imaging Reflectometer for an investigation into the effects of calendering on a lightweight clay-coated paper. The application illustrates how the various measured parameter can be used to give insights into the structure of the coating layer.

Samples
Samples of lightweight paper, pilot coated with a kaolin pigment were calendered using a laboratory calender at various numbers of nips. The calender comprises a heated polished steel roller in contact with a slightly deformable roller. Paper passing through the calender is compressed resulting in an increase in smoothness and gloss. Parameters affecting the surface finish include calender temperature, pressure and the number of times the paper is passed through (number of nips). In this experiment here, only the number of nips was varied. Samples were kindly provided by Imerys Minerals Ltd, Paper Group.

Parameters measured
- Refractive index
- Gloss (based on 2-d integrated area of reflectogram)
- Macroroughness (width of the reflectogram in-plane and out-of-plane)
- Microroughness (by two-wavelength method)

Results
Measurements were made on 10 points over a sample approximately 6 x 4 cm. The following figures show the basic results. Error bars on the plots represent the standard error of the 10 measurements. In most cases measured parameters are plotted against Tappi gloss as this provides the most useful interpretation. Figure 1 shows how gloss varies with number of nips.

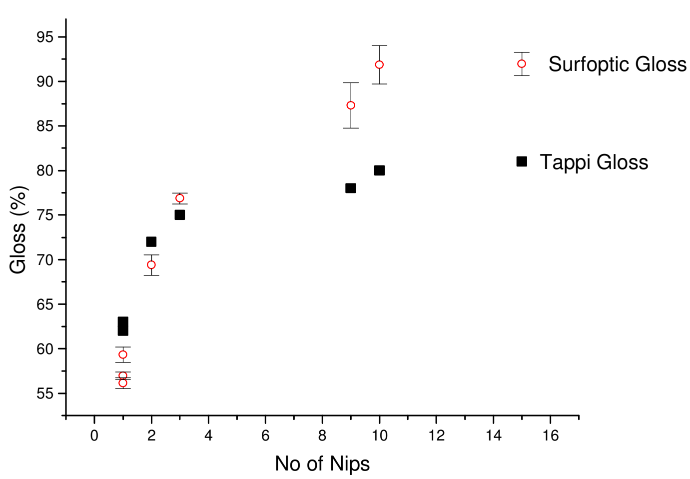

Figure 1
Variation of gloss with number of nips. Shown are Tappi paper gloss and Surfoptic gloss, a gloss based upon the integrated 2-d reflectogram. The first few nips have a pronounced effect on the paper gloss, which tends to plateau as the number of nips increases above about 5. (note at the moment the value of the Surfoptic "gloss" is not defined formally)

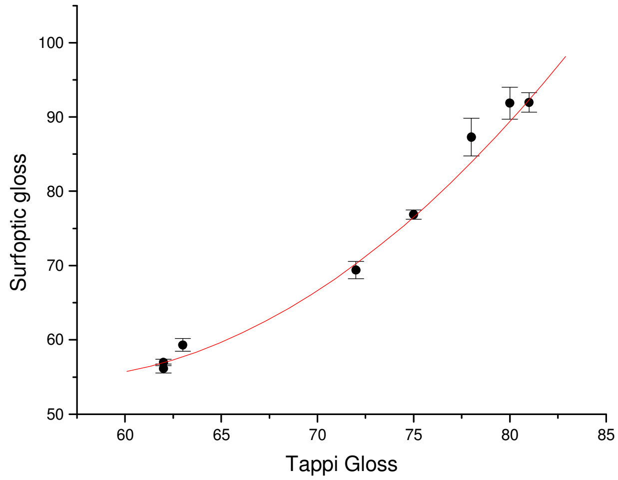

Figure 2
Correlation between Tappi Gloss and Surfoptic gloss. The relation is not linear, but the geometry is rather different, the reflectometer uses a monochromatic source whereas the gloss meter uses white light, and the samples might have changed physically since the original glosses were measured.

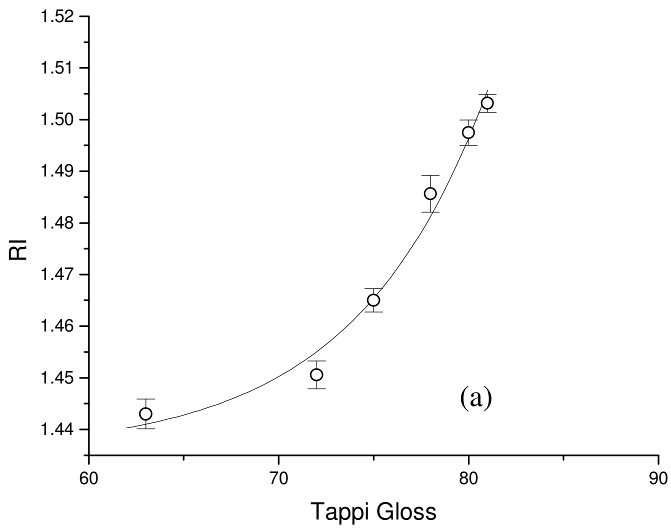

Figure 3
The refractive index increases with increasing number of nips. Each successive pass through the calender tends to compress the basesheet and coating. As the coating is compacted, so the refractive index increases owing to a greater ratio of clay pigment to air.

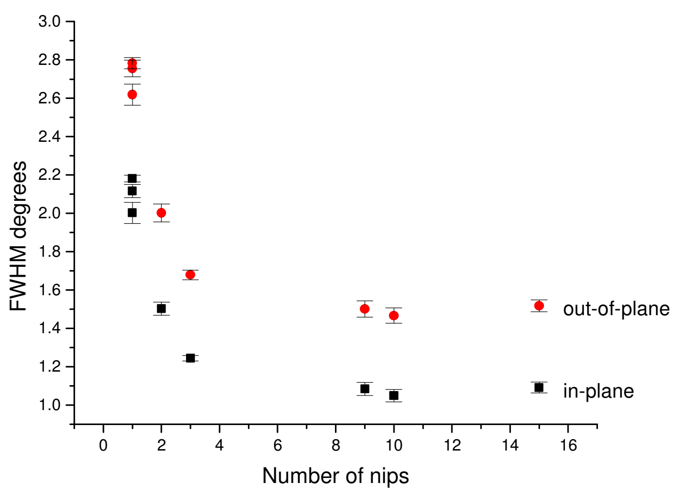

Figure 4
The FWHM of the reflectogram decreases rapidly with increasing nips, reaching a level beyond about 5. Strictly, FWHM should not have any effect on gloss so long as the whole reflectogram is contained within the acceptance angle of the gloss measuring device. The data show that the first few nips have the greatest effect on the basesheet (fibre) macroroughness.

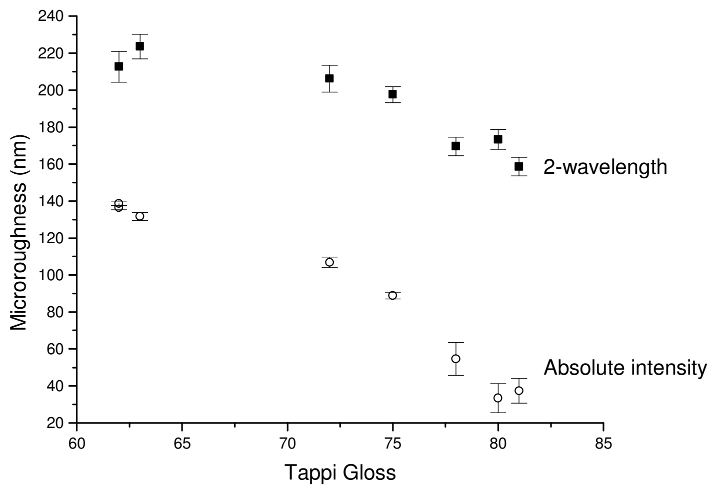

Figure 5
Microroughness as measured by Surfoptic reflectometer using two calculation methods. The absolute values do not agree owing to lack of common calibration at the time of these experiments. However, the trends are similar (see discussion below for comment)

Discussion of paper results

As the number of nips increase beyond a certain number, the FWHM (macroroughness) begins to level off. The profile of the reflectogram is attributed to the facet-like distribution of reflecting planes at the coated paper surface. There is a contribution from both fibre macroroughness and clay plate misalignment. So long as the greater part of the reflectogram is contained within the angular acceptance of the gloss measuring device, changes in facet distribution FWHM should not affect gloss. The Tappi acceptance angle is $\pm 5^o$, about the same as that of the new reflectometer, so gloss changes should not be significantly due to macroroughness changes.

Microroughness, attributed to fine scale optical roughness of the coating pigment, decreases slowly, then more rapidly with increasing nips. The refractive index increases slowly initially, but then more steadily with increasing nips. This observation is summarised in Figure 6. The first few passes through the calender tend to compress the base sheet. Only when the basesheet has been compressed does calendering have significant effect on the coating layer which becomes smoother (lower microroughness) and compacted (higher refractive index).

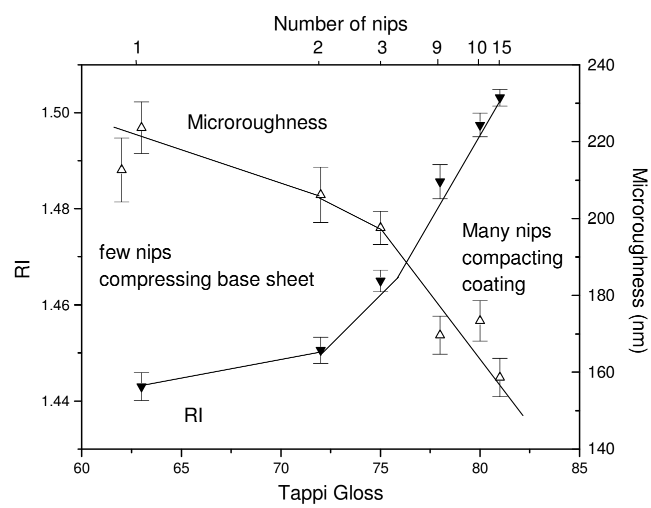

Figure 6
Summary of RI and microroughness behaviour with increasing gloss (and nips).