Improving Metallic Ink Printing through Polarized Densitometry

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Abstract: Metallic inks have long been used to enhance the value and convey quality of the printed piece. As with any ink, it is necessary to measure the optical density of the ink with a densitometer or spectrodensitometer to ensure correct color and print quality. It had been determined that densitometer readings for metallic inks among several instruments out on the market did not correlate well if the ink film thicknesses were varied. Understanding the correct readings help in preventing set off in the stack, insufficient drying of ink in web presses, better control of ink and water balance, and yield more consistent results between printed pieces. This study suggests that the employment of a polarized light filter in a reflection based densitometer or spectrodensitometer provides a better representation for comparing optical density values to ink film thicknesses than those instruments without such filters. Comparative test results of different makes of densitometers with and without polarized filters are discussed and shown via various graphic charts and pictures.

The Problem

It is common understanding that the optical density of metallics cannot be measured with the same densitometers or spectro-densitometers used for conventional process colors. Printers rely on their eye to make judgments, but sometimes this does not reflect the reality. Film weights are printed often that are too high or low, which create various technical problems like incomplete drying, blocking, chalking or insufficient adhesion of over-coatings or laminates. The following describes ways to obtain correct ink density readings with commercially available instruments.

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The Hypothesis I

Metallic pigments are by nature completely different than others used in printing (see Figures 1 and 2). The pigments are flake-shaped, fully opaque and significantly larger. They consist of planar areas designed to reflect as much light as possible in order to create metallic sheen or luster. The additional light reflection from the pigment surface versus substrate surface influences the accuracy of the densitometer reading. The higher the film weight printed the higher the degree of reflection leading to an overall reduced densitometer reading. At a critical level the readings become completely unreliable.

Fig. 1 Magnified metallic print, cross-sectional view

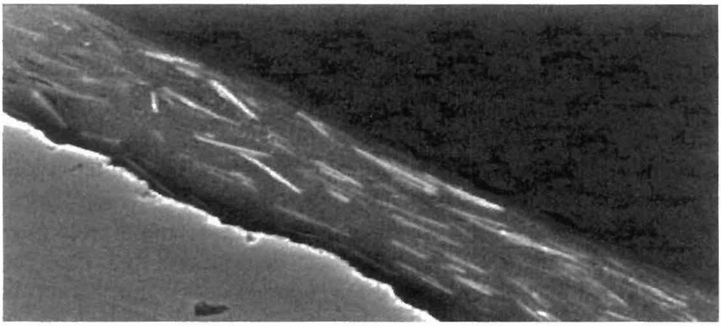
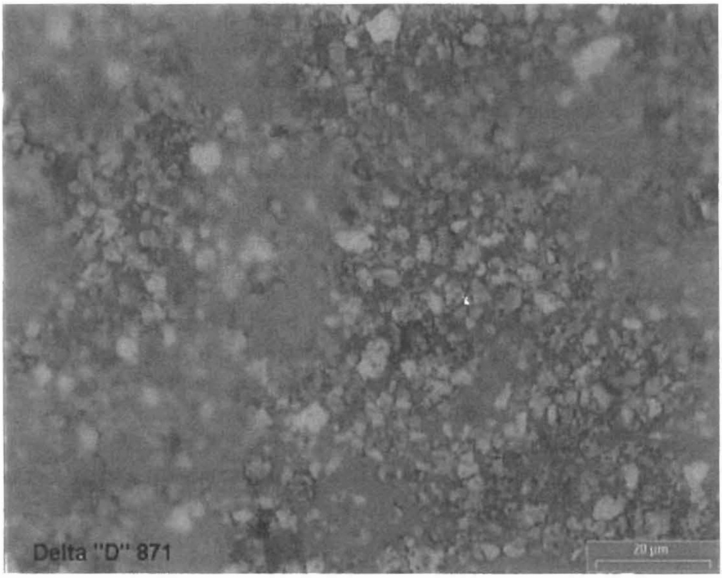
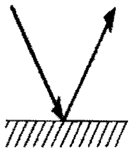


Fig. 2 Magnified metallic print, topical view

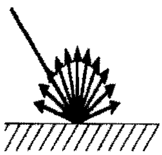


The illustrations in Figure 3 indicate types of reflection expected for various surfaces. Perfectly specular reflection would result from a mirror-like or perfectly planar surface. Imperfect surfaces of coatings and coatings containing pigments of irregular or spherical shapes lean towards 100% scattering. Coatings containing metal leafing metallic pigments exhibit a combination of both reflection and scattering properties.

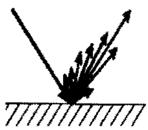
Fig. 3 Three differing examples of types of reflection.



perfectly specular surface:
100 % reflection



perfectly dull surface:
100 % scattering



metal effect:
reflection and scattering

The table titled "Chemical Makeup of Metallic Pigments" illustrates the various types of metal alloys used in the graphic arts industry and a description of each alloy. The types of alloys focused on in this study were aluminum, rich gold, and pale gold. Each of these alloys was evaluated in a typical offset and gravure formulation.

Table-1 Chemical Makeup of Metallic Pigments
Gold bronze pigments

Natural colour	Alloy	Colour
copper	copper = 100 %	copper red
pale gold	copper:zinc = 90:10	reddish yellow
rich pale gold	copper:zinc = 85:15	yellow
rich gold	copper:zinc = 70:30	greenish yellow
Aluminum pigments		
silver	aluminum = 100%	hueless

Metallic pigments are produced in a variety of particle sizes. The larger the flake size, the greater the degree of brilliance. Metallic flakes used in the graphic arts industry vary from 3 to 15 μm. In this study pigment types of 3 μm (offset inks) and 7 μm (gravure inks) were studied.

Aluminum pigments can be produced by a variety of means. Typical aluminum pigments found in the graphic arts industry are produced by wet grinding (Hall process). Other means of production such as physical vapor deposition can produce flatter and therefore more brilliant products. This study evaluated aluminum and bronze pigments from conventional processes.

The Hypothesis II

Reflection densitometers (Leach and Pierce, 1993) compare the light reflected from the unprinted substrate surface to the light reflected from the printed surface. The light extinguished by the pigment is responsible for the color density. The measurement is only correct on less reflective ink surfaces.

Densitometer readings are calculated as: $D = \log_{10} I_0/I_1$

I_0= light intensity reflected on white substrate
I_1= light intensity reflected through ink

Polarization filters in the densitometer should be suitable to suppress the surface reflection.

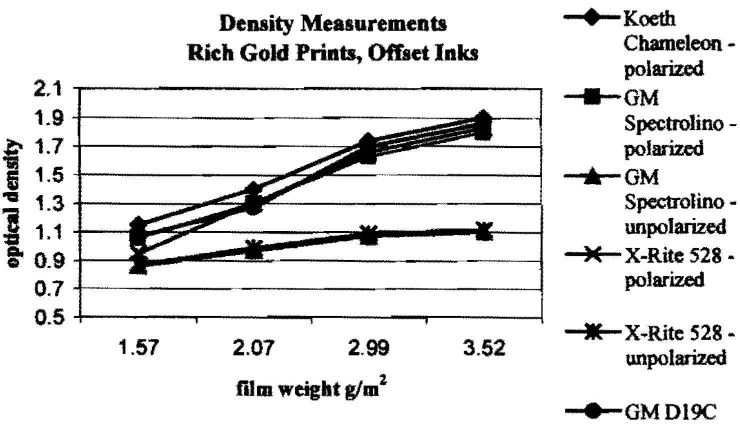
Problem Solution

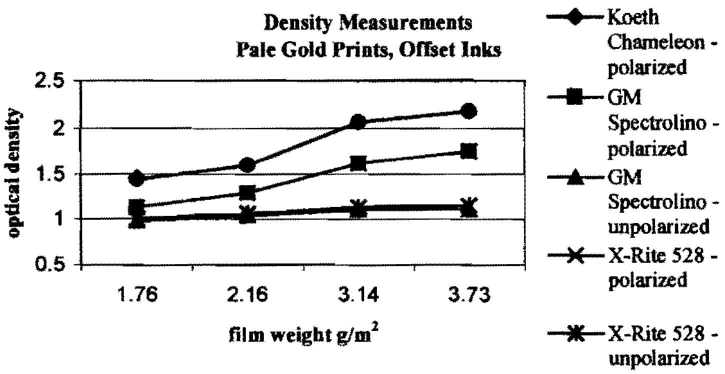
In a study conducted the following randomly selected commercially available instruments were tested measuring metallic prints of various film weights:

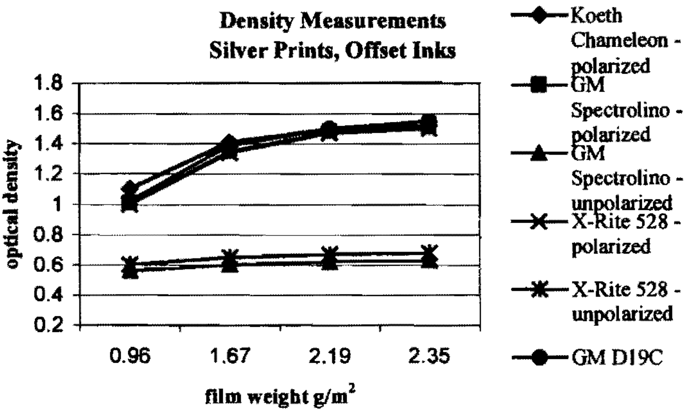
GretagMacbeth Spectrolino
Spectrophotometer
GretagMacbeth D19C
Densitometer
X-Rite SP 60 series
Sphere Spectrophotometer
X-Rite 528
Spectrodensitometer
Koeth Chameleon
Densitometer

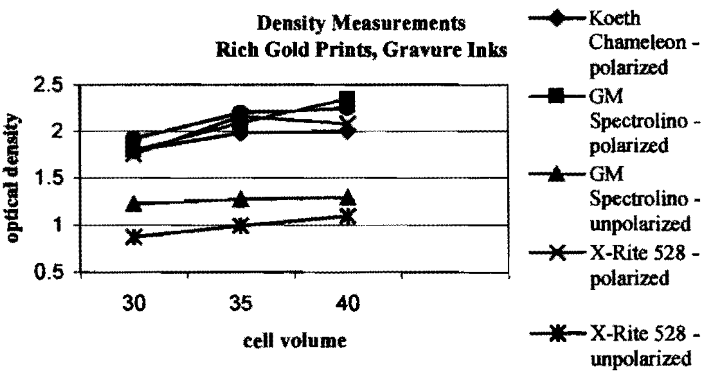
For each of the densitometer measurements, the black filter was selected when measuring silver colored inks and the yellow filter was selected for the rich and pale inks. The black filter for silver inks and the yellow filter for gold inks yields the best results in terms of which colored filter to use, but the addition of a polarized light filter was tested in order to determine if more accurate results were obtained.

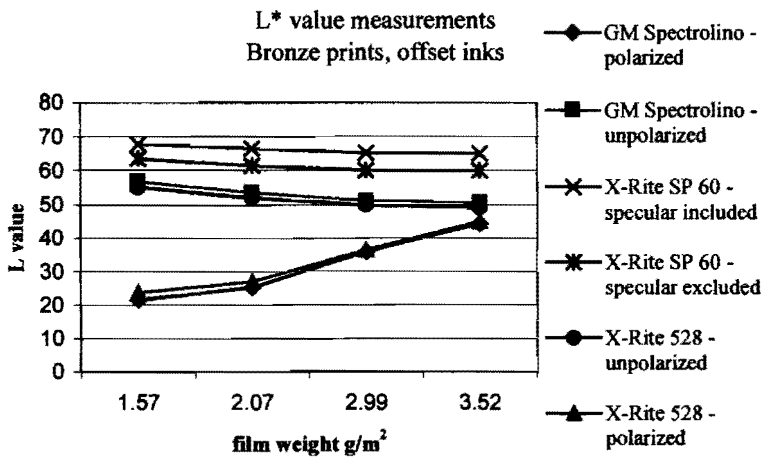
The following five graphs illustrate the results obtained.




Density Measurements
Pale Gold Prints, Offset Inks
optical density
2.5
2
1.5
1
0.5
1.76
2.16
3.14
3.73
film weight g/m²
Koeth Chameleon - polarized
GM Spectrolino - polarized
GM Spectrolino - unpolarized
X-Rite 528 - polarized
X-Rite 528 - unpolarized


Density Measurements
Silver Prints, Offset Inks
optical density
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0.96
1.67
2.19
2.35
film weight g/m²
Koeth Chameleon - polarized
GM Spectrolino - polarized
GM Spectrolino - unpolarized
X-Rite 528 - polarized
X-Rite 528 - unpolarized
GM D19C


Density Measurements
Rich Gold Prints, Gravure Inks
optical density
2.5
2
1.5
1
0.5
30
35
40
cell volume
Koeth Chameleon - polarized
GM Spectrolino - polarized
GM Spectrolino - unpolarized
X-Rite 528 - polarized
X-Rite 528 - unpolarized



Conclusion

It was determined that the measurement of optical densities for metallic inks had varied among several types of densitometer and spectro-densitometer instruments. In the process of investigating this phenomenon two hypothesizes were formed. The first hypothesis claims that the higher the film weight of a metallic ink, the higher the degree of reflection. This idea is supported by results obtained from different instruments and the physics of metallic ink films. The second hypothesis states in essence that polarized light filters are necessary to extinguish the high degree of reflected light caused by metallic inks in order to produce both accurate and precise readings. This idea was supported by evaluating instruments of different manufacturers and geometries with and without the polarized light filter. It is also seen that exclusion of specular reflectance cannot accurately display differences in film weight of a printed ink. The effect of calculation methods, light sources, and various metal alloys were also explored, and this preliminary evidence gathered also points toward the necessity of polarized light filters. Further testing may be explored to determine any other possible effects on determining the color density of metallic printing inks, and for inks based on vacuum metallized aluminum pigments.

Acknowledgements

Color Control Systems, Paul Flaig and X-Rite, David Benner

Literature Cited

Leach, R.H. and Pierce R.J.
1993 "The Printing Ink Manual" (Blueprint, an imprint of Chapman and Hall), 5th ed., pp. 107-110.