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Verifying Process Ink Conformance by Means of a Graduated Gauge

Keywords

density, calibration, IFT, color

Abstract

To justify ink conformance to a standard, many ink film samples with various known ink film thicknesses (IFT) should be produced by use of a printability tester. The ink will pass if at least one ink film sample with a thickness within the range of 0.7 to 1.1 microns (0.7-1.3 for black ink) has less than 4 ΔE color difference from the aim points specified by ISO 2846 standard. One of the current ink transfer mechanisms recommended by ISO 2834 is an IGT printability tester. However, it is time consuming to produce enough number of ink samples. A sample produced by a Little Joe proofer, on the other hand, has multiple IFTs (ink film thickness) within a single sample. But they are not absolute values. This paper is to generate a calibration curve of density vs. IFT of an ISO-certified brand of magenta ink. Once the calibration curve of the ink is available, a density on a sample produced by a Little Joe proofer can be transferred to a known IFT according to the calibration curves.

1 Introduction

Nowadays, more and more people are talking about the use of standardization within the printing industry. However, to standardize printing, materials such as inks should be standardized first. *Good* (quality) inks should be used, because *bad* (poor quality) inks have fewer pigments which means more ink film thickness is needed to achieve a certain color (???).

ISO 2846-1:2006 Graphic technology – Color and transparency of ink sets for four-colour printing – Part 1: Sheet-fed and heat-set web offset lithographic printing defines what a *good* offset process ink will be like by a set of colorimetric specification. To verify a process offset ink, ISO 2834 defines a currently widely used method. However, this method is tedious and time consuming (citation).

This paper developed an alternative method for process offset inks verification. An ISO-certified magenta ink was used, and the samples were produced by the ISO 2834 method using an printability tester manufactured by IGT Testing Systems. A calibration curve of the relationship between density and ink film thickness was generated, and then a Little Joe proofer was used to produce a sample with multiple ink film thicknesses. Density and CIELAB were measured and density was converted to ink film thickness through the calibration curve.

The ink film thickness (IFT) at each ink volume is respectively 0.42, 0.53, 0.66, 0.71, 0.93 and 1.06 μ (Table 2).

2 Methodology with Results

The following methodology was used to generate the calibration curve of the ink and to verify the conformity of the ink by its calibration curve.

2.1 Calibration Curve Generation

Generation of the calibration curve required (1). determination of the mass density of the ink; (2). Production of the ink samples;, (3). calibration of IFT; and (4). generation of the calibration curve.

2.1.1 Determine the Mass Density of the Ink

- Fill the pipette compactly with the ink to be tested: magenta manufactured by Superior Printing Ink Co., Inc..
- Place a 3x3 glass board on the scale with the accuracy better than 0.1 mg and zero the scale with the glass board on it.
- Squeeze 2 cc volume of the magenta ink with pipette to the glass board, after the scale is stable, and record the weight of the 2 cc ink, denoted as W.
- Note that the mass density of the ink is equal to W/2; the unit is mg/cc (Table 1).

Ink Volume	Weight (W)	Mass Density
2	2.099	1.0495

Table 1. Mass density of the magenta by Superior Printing Inks.

2.1.2 Produce Ink Samples

- Mount a test strip on the sector of IGT AIC2-5T2000 printability tester.
- Squeeze 0.04 cc ink with pipette to the distribution rubber roller of IGT High Speed Inking Unit 4, and start the inking unit to distribute the ink for 10 seconds.
- During the 10-second distribution time, place the printing disc on the inking unit.
- Place the disc on the scale after 5 seconds when the ink is transferred from distribution roller to the disc. Record the weight of the disc with the ink, denoted as W1.
- Take the disc off the precision scale and place it on the top shaft of the printability tester, and turn the sector to the printing position.
- Print by holding the buttons on both sides of the IGT printability tester.
- Place the disc with rest of the ink on the precision scale and record the weight of it, denoted as W2.
- Clean the disc and rollers of inking unit for the next test.
- Repeat Steps a through j to produce more ink samples. Change the ink volume at Step b as 0.05 cc, 0.06 cc, 0.07 cc, 0.08 cc, 0.09 cc, 0.11 cc.
- Make another 4 sets of 7 samples by repeating Steps a to i.

2.1.3 Calculate IFT (Ink Film Thickness)

Calculate the transferred weight of the ink by W1-W2 for each one of the five sets. Then average the 5 sets at each input volume.

Since mass density was determined in Section 2.1.1, note that the transferred ink volume is equal to averaged transferred ink weight divided by mass density: ΔW/1.0495.

The print area is 72 square million meters that is calculated by the length timing width.

Calculate IFT at each ink input volume:
IFT= (Averaged (W1-W2)/ (1.0495x72)) x10000

Input vol.(cc)	0.04	0.05	0.06	0.07	0.08	0.09	0.11
Transferred vol.	0.0032	0.004	0.005	0.005	0.006	0.007	0.008
IFT(u)	0.42	0.53	0.66	0.71	0.79	0.93	1.06

Table 2. Ink input volume vs. averaged ink transferred to the strip and IFT.

- The ink film thickness (IFT) at each ink volume is respectively 0.42, 0.53, 0.66, 0.71, 0.93 and 1.06 μ (Table 2).

2.1.4 Generate the Calibration Curve

Measure density on each of the 7 samples in Set 1 three times. Average three densities at each IFT in Set 1. Then do the same to the remaining four sets. At each IFT, density will be varied due to the experimental error uncertainty of the IGT system, so the uncertainty of the density at each IFT level will be calculated in terms of standard deviation. Table 3 shows the density at each IFT level as well as the uncertainty in terms of standard deviation

Density	IFT	IFT - 2σ	IFT + 2σ	CIELab			ΔE
				L*	a*	b*	
1.07	0.45	0.43	0.46	54.68	69.95	-7.3	8.78
1.2	0.52	0.5	0.54	52.5	73.34	-5.75	4.57
1.35	0.61	0.59	0.63	50.26	75.92	-3.59	0.65
1.49	0.71	0.68	0.74	48.51	77.85	-0.5	3.45
1.53	0.74	0.72	0.77	48.07	78.23	0.98	4.96
1.68	0.9	0.86	0.94	46.81	79.7	4.98	9.36

Table 3. Density at each IFT for each set with averaged density and standard deviation.

According to the uncertainty of the system, the calibration curve of the ink will not be a single curve. Average densities at each IFT level and draw the averaged calibration curve. Then add the uncertainty to the averaged calibration curve to form upper limit of the calibration curve, and subtract the uncertainty from the averaged curve to form the lower limit curve. Lastly, measure the corresponding CIELAB and calculate color difference from ISO 2846 magenta offset ink colorimetric specifications: L*= 50, a*= 76 and b*= -3. Table 4 shows upper and lower limits of densities, CIELAB and ΔE at each IFT level.

Input vol. (cc)	0.04	0.05	0.06	0.08	0.09	0.11
IFT (μ)	0.42	0.53	0.66	0.79	0.93	1.06
1st set Averaged D	1.03	1.24	1.39	1.61	1.64	1.77
2nd	1.04	1.22	1.38	1.62	1.69	1.8
3rd	1.01	1.22	1.37	1.65	1.66	1.81
4th	1.05	1.24	1.39	1.61	1.68	1.81
5th	1.06	1.23	1.39	1.61	1.66	1.79
Averaged D at each IFT	1.04	1.23	1.38	1.62	1.67	1.8
Standard deviation	0.0199	0.0083	0.0268	0.0162	0.021	0.0177

Table 4. Averaged, upper and lower limit densities at each IFT level for the magenta ink. The corresponding CIELAB and ΔEs are also listed.

Figure 1 shows the calibration curve of the magenta ink.

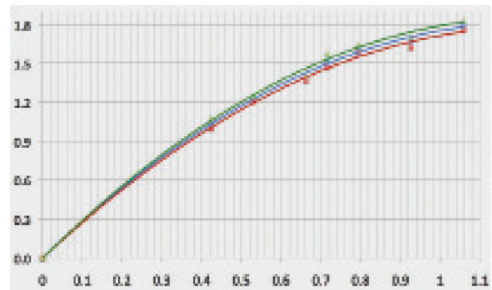

Figure 1. Calibration curve of Superior magenta ink. The blue curve in the middle comes from the averaged density vs. IFT, the top one from averaged density+2σ vs. IFT and the bottom one from density-2σ vs. IFT.

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3 Verification of the Ink

The ISO 2834 method and the calibration curve were used to verify the ink.

3.1 Using ISO 2834 Method

Use the averaged IFTs and their corresponding ΔEs to draw the U-shaped ink qualification curve. The curve is shown in Figure 2.

ISO 2834 does not take the uncertainty of the printing system into account, therefore the middle blue U-shaped curve is actually the final ink qualification curve for the ISO 2834 method, and according to it, this magenta ink passes ISO 2846 colorimetric specification.

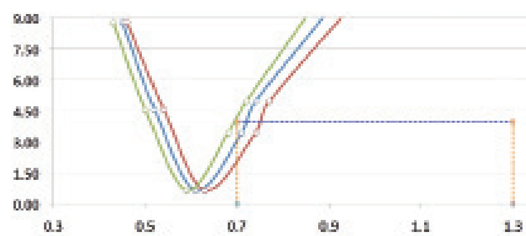

Figure 2. The U-shaped ink qualification curves of ΔE vs. IFT. ΔEs are from color difference between aim points specified by ISO.

3.2 Using the Calibration Curve

- Produce a multi-IFT sample by a Little Joe proofer.
- After 24-hour dried, measure spectral date at 100 spots along the sample with i1 pro.
- Calculate CIELAB values and densities at each spot based on the spectral data.
- Randomly select 6 six spots, record their densities and CIELAB.
- Find out the corresponding IFT through the calibration curve by the densities. The density, CIELAB and converted ink film thickness is listed in Table 5.

Density	IFT	IFT - 2σ	IFT + 2σ	CIELab L*	CIELab a*	CIELab b*	ΔE
1.07	0.45	0.43	0.46	54.53	68.58	-5.44	8.98
1.2	0.52	0.5	0.54	51.73	72.37	-2.88	4.02
1.35	0.61	0.59	0.63	49.63	75.12	-0.13	3.02
1.49	0.71	0.68	0.74	47.86	76.75	3.26	6.66
1.53	0.74	0.72	0.77	47.38	77.31	4.05	7.63
1.68	0.9	0.86	0.94	45.87	78.6	7.69	11.75

Table 5. Six densities that are the same as the six samples above, with averaged IFT, IFT ±2σ, CIELAB values and ΔE from the aim points specified by ISO 2846.

- Calculate color difference between measured CIELAB at each spot and the ISO 2846 magenta standard and list each ΔE as shown in Table 5.

- Plot the curves of ΔE vs. IFT, ΔE vs. IFT+2σ and ΔE vs. IFT-2σ. (Figure 3)

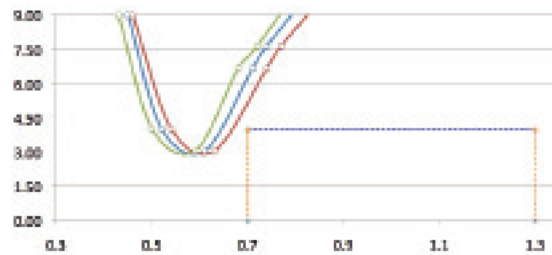

Figure 3. The U-shapede ink qualification curve. ΔE is the color difference between the measured CIELAB at each spot and ISO 2846 specification, and IFT is from the conversion through the calibration curve by the density at each spot.

4 Findings

Analysis of results obtained by using a graduated gauge highlights two area: uncertainty within the system due to standard deviation and verification of the ink by using the calibration curve.

4.1 Uncertainty of the System

Theoretically, a density is supposed to correspond to only one IFT, hence the calibration curve is supposed to be a single curve. However, due to the uncertainty of the ink transfer mechanism and human error, calibration curve of an ink will be like the one seen in Figure 1.

According to the empirical rule of statistics, "95.44% of the values lie within 2 standard deviation of the mean (http://en.wikipedia.org/wiki/68-95-99.7_rule)." That is why 2σ was added to and subtracted from the averaged calibration curve. The range between upper and lower curve includes 95% possibility of IFT at a given ink input volume level. According to Table 3, the uncertainty varies over all input levels, and the averaged uncertainty of the IGT system is 4*0.0177=0.0708. In other words, this is the averaged distance between the two limits of the calibration curve.

4.2 Ink Verification by the Calibration Curve

According to Tables 4 and 5, at the same density, the CIELab values are different between a sample that is produced by IGT and a spot on a multi-IFT sample that is produced by a Little Joe proofer. This shows that due to the ink transfer mechanism change, the same ink and same paper could produce different color at the same density.

5 Future Study

The same ink and paper should yield the same color at the same density in theory, but the result was not the case. One of the reasons for this result might be the impurity contained in the Little Joe proofer. For cleaning, only solvent is used in the IGT system, but alcohol is used for the second cleaning in the Little Joe system after the system is cleaned using the solvent. In the future, the alcohol should not be used to clean the Little Joe proofer.

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