

Tone Reproduction Characteristic of Digital Printing

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Abstract

Digital printing has the advantages of variable data, printing according to the demand, individuation service. Therefore, its appropriation in the market of printing field is increasing year by year, and its quality draws near to the offset printing. This paper carries out experiment and does research into the tone reproduction characteristic on the color representation ability of Indigo3500 based on electric ink printing and Canon 7000VP digital printing machine based on carbon powder printing. By obtaining the dot characteristic curve and color gamut range and comparing its offset printing effect with Heidelberg CD102, this paper gets the conclusion: Each tone's dot gain curve of digital printing has the same variation tendency, the tone rendition of digital printing can simulate the offset printing effect. Color gamut has apparent discrepancies. the color gamut of Indigo3500 is relatively broader, which can contain the offset printing color gamut. The color gamut range of Canon 7000VP is close to offset printing, but its color gamut range is apparently different. From the aspect of printing quality, the product of digital printing can meet the needs of common offset product. But from the aspect of microcosmic quality, the dot structure of carbon powder printing is not ideal, whose visual sensation is relatively inferior. The dot of electric ink is identical to the offset printing, whose visual sensation is close to the offset printing.

1. Preface

These years, digital printing facilities increasingly come out, whose application field gradually extends from handle official work, video making to individuation commercial printing and packing. It complements the offset printing technique, which creates the market structure of multi-printing product. What are the discrepancies of the product quality from different printing methods? Whether they can be replaced by each other? These are questions that we care about. This paper chooses electric ink digital printing machine and carbon powder printing machine to carry out experiment and analyze the data, and then compare the product with the offset printing product. Finally it evaluates the tone reproduction characteristic, color representation ability and the product's visual sensation of the digital printing machine.

2. Experiment and data analysis

2.1 Experiment facility and material

Canon 7000VP digital printing machine, HP Indigo 3500 digital printing machine, Topsetter102CTP, CD102 offset printing machine, X-Rite 530 densitometer, X-Rite I1 isis spectrometer, Profile Maker5 color management software, Jindong 157g art paper.

2.2 Experiment process and method

2.2.1 Testing file

Make the testing file as Fig.1 shows, which contains three parts: CMYK color signal bar, CMYK color scale, ECI2002 chart. Each part's functions are as follows:

CMYK color signal bar: to measure the four color density and printing prospectus uniformity.

CMYK color scale: set a color block every 5 percentage to measure each tone's dot gain value. In order to test the rendition effect of the highlight better, set a color block every 1 percentage.

ECI2002 chart: in order to measure the color gamut range of digital printing, compare the color gamut range of each digital printing machine which has the same type and the same model.

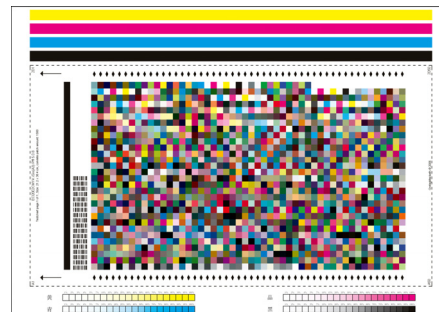


Fig.1. Testing file

2.2.2 Experiment process

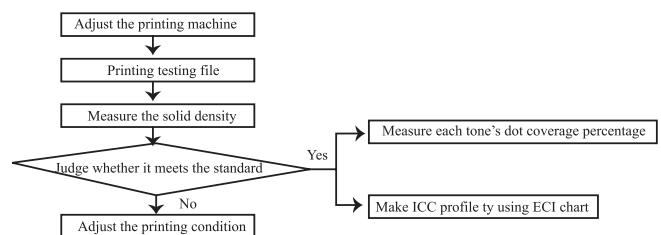


Fig.2 The experiment process

According to the need of research, this experiment designs the process as Fig.2 shows to obtain the data to analyze. Firstly, when the printing machine reaches the steady working condition, test the printing file. Control the quality of printing prospectus according to the standard density cyan 1.50-1.60, magenta 1.40-1.50, yellow 1.05-1.15, black 1.65-1.75. After printing, measure the data of the prospectus, and the make ICCProfile file by using ECI chart, obtain the printing color gamut range, finally get the tone reproduction data by using the dot scale.

2.3 Experiment data

2.3.1 Solid density

Solid density is defined as the dot coverage on the printing product is 100%, which means the section totally covered by ink. The density is measured by using reflectance densitometer. The value of density reflects the image and character's thickness. The thicker the ink is, the higher the density value will be, or lower it will be. The solid density data is shown in Tab.1, which is within the standard density range.

Tab. 1 Printing solid density

Ink color	Standard solid density	Measured solid density		
		Canon 7000VP	HP Indigo 3500	CD102
Cyan	1.50-1.60	1.60	1.55	1.52
magenta	1.40-1.50	1.49	1.42	1.42
Yellow	1.05-1.15	1.15	1.08	1.12
Black	1.65-1.75	1.75	1.69	1.72

2.3.2 Tone dot gain value

Tone dot enlarge value is defined as the distortion between the dot area on the printing product and the corresponding section on electrical file. The variation of dot size will directly influence the printing tone rendition and color rendition. The measured dot gain value are as Tab. 2-Tab.5 and Fig.3-Fig.6 shows.

Tab.2 Cyan ink's dot gain value of three printing machines

Plate (%)	5	10	15	20	25	30	40	50
CD102 (%)	8	12	18	27	30	37	48	60
Indigo3500 (%)	10	19	25	34	41	47	58	69
Canon7000VP (%)	6	12	18	22	27	35	46	64
Plate (%)	60	70	75	80	85	90	95	100
CD102 (%)	73	81	83	88	90	94	97	100
Indigo3500 (%)	76	83	86	90	92	96	98	100
Canon7000VP (%)	61	73	80	84	90	93	98	100

Tab.3 Magenta ink's dot gain value of three printing machines

Plate (%)	5	10	15	20	25	30	40	50
CD102 (%)	7	13	20	25	32	36	48	57
Indigo3500 (%)	7	17	22	29	37	43	55	65
Canon7000VP (%)	6	14	20	25	32	37	48	60
Plate (%)	60	70	75	80	85	90	95	100
CD102 (%)	72	80	82	86	89	94	97	100
Indigo3500 (%)	74	83	85	88	92	96	98	100
Canon7000VP (%)	67	78	84	89	92	95	98	100

Tab.4 Yellow ink's dot gain value of three printing machines

Plate (%)	5	10	15	20	25	30	40	50
CD102 (%)	7	15	23	31	39	43	54	65
Indigo3500 (%)	8	15	22	30	40	45	58	68
Canon7000VP (%)	6	12	19	25	28	38	48	60
Plate (%)	60	70	75	80	85	90	95	100
CD102 (%)	76	85	88	91	93	97	99	100
Indigo3500 (%)	77	83	85	88	92	95	98	100
Canon7000VP (%)	65	76	83	87	91	95	98	100

Tab.5 Black ink's dot gain value of three printing machines

Plate (%)	5	10	15	20	25	30	40	50
CD102 (%)	8	14	20	27	35	38	50	60
Indigo3500 (%)	7	16	25	33	39	45	56	68
Canon7000VP (%)	6	12	18	28	34	40	53	64
Plate (%)	60	70	75	80	85	90	95	100
CD102 (%)	72	74	81	87	90	95	98	100
Indigo3500 (%)	76	84	87	90	93	96	99	100
Canon7000VP (%)	73	83	87	91	94	97	99	100

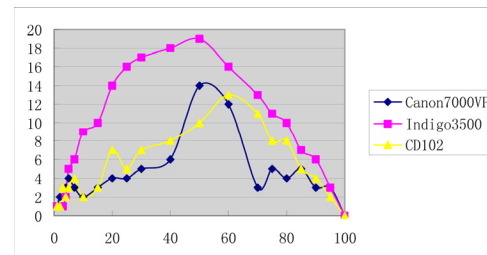


Fig.3 Cyan ink's dot gain curve of three printing machines

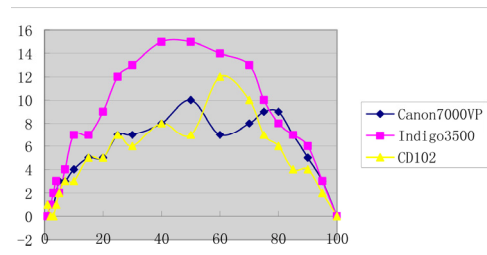


Fig.4 Magenta ink's dot gain curve of three printing machines

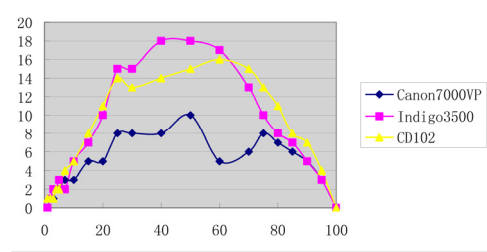


Fig.5 Yellow ink's dot gain curve of three printing machines

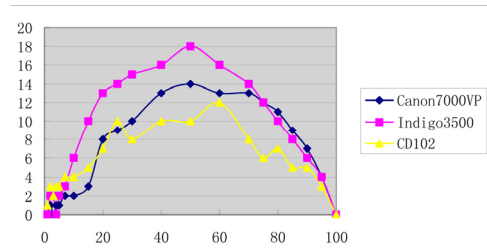


Fig.6 Black ink's dot gain curve of three printing machines

2.3.3 Color gamut range

The color gamut range of facility determines the color range that it can represent. Color gamut range is relevant to facility's color rendering ability, ink and paper etc. This experiment

uniformly uses 157g art paper to print ECI2002 chart, measure and calculate to get the three facilities' ICC file. Three printing machines' color gamut ranges are shown in Fig.7.

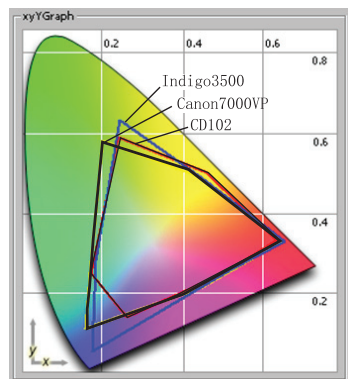


Fig. 7 Three printing color gamut

2.3.4 The microstructure of dot

Fig.8 shows the printing product's dot structure taken by the photomicroscope. From the left to the right are part of the printing prospectus of CD102, Indigo3500, and Canon 7000VP.

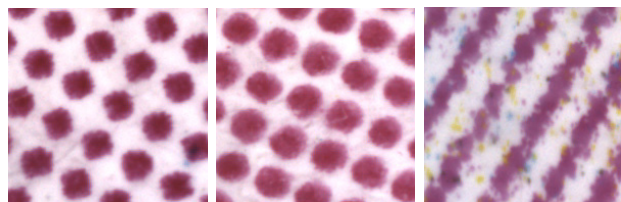


Fig. 8 Dot microstructure of CD102, Indigo and canon7000VP printing prospectus

2.4 Experiment data analysis

2.4.1 Tone reproduction capability

From the Fig.3-Fig.6, the dot gain value of the three printing machines' yellow, magenta and cyan ink are all controlled within the standard regulation that 50% dot gain cannot exceed 20%. Black dot gain value is controlled within the standard regulation that 50% dot gain cannot exceed 25%. Digital printing dot gain curve has the parabola shape which is similar to offset printing, whose tone rendition can basically simulate offset printing effect. But digital printing has a common disadvantage: it cannot represent each tone and administrative level in the highlight, especially for Canon7000VP, its dot gain value shows relatively severe dithering in the whole tone.

2.4.2 Color representation ability

As Fig.7 shows, color gamut ranges of the three printing prospectus have apparent discrepancies. Two types of digital printing machines have inferior color representation ability in the yellow zone while have superior color representation ability in the blue zone. Indigo3500 has wider color gamut range, which can

contain offset printing color gamut. The color gamut range size of Canon 7000VP is close to offset printing, but the color gamut range it can represent is greatly different. Except the yellow zone, others can basically contain offset printing color gamut range. Therefore, when it is used in offset proof, Indigo3500 is superior to Canon7000VP.

2.4.3 Visual effect

From the aspect of quality, the two printing products can meet the needs of common offset printing. But from the micro-quality of Fig.8, the dot brim structure of carbon powder printing is not ideal. There is dirt in the blank part, and has inferior visual sensation effect. The dot of electric ink is identical to offset printing, which has the similar visual sensation effect to offset printing.

3. Conclusion

This research shows that color printing products can be made by offset printing or digital printing according to the practical needs, in which, Indigo3500's printing effect is similar to offset printing. It can be used in image printing and digital proof. Canon 7000VP can meet the needs of common color printing, but it has great difference in color gamut range with offset printing, which is not suitable to offset proof. On the other hand, as the two digital printings are both based on the principle static imaging, which needs severe electricity pressure stability at the moment of imaging while needs severe temperature stability in carbon powder, how to ensure the product's stability of digital printing is critical for digital printing to win offset printing.

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