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A study of the effect of substrate on dot-matrix printing

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1. Introduction

Forensic document examiners are regularly called upon to give opinion on printed matter as their work is not limited to the examination of only handwriting samples. Submission of computer generated documents in question has increased these days due to high usage of computers and development of huge range of printing technologies. Research has been carried out with an aim to analyze dot matrix printing and characteristics of printed documents. This can aid in the identification of printer used for printing the document. Dot matrix printer creates an image through mechanical impact on the paper. The physical examination of printers in-

cludes a general assessment of printing technology, which can be achieved by microscopic examination. A little work has been conducted for the identification of documents printed by these printers through physical examination, that is, on the basis of printing characteristics/ physical defects (Leslie and Stimpson 1982; Gilmour and Purdy 1998; Blanco 1993). Eckert (1997) has demonstrated identification of the printer with a specific dot pattern to produce letters on the paper. The study states that pins may produce unique defects with the passage of time, aiding in the identification of printers. Laporte (2004) has discussed the effect of substrate (paper) on the printed matter in case of Inkjet printer. The study demonstrates that the use of different substrates can have a dramatic influence on printing characteristics. Thus, it is crucial for the document examiners to be aware of these facts, especially in cases related to the comparison of multiple documents, which consists of different types of papers.

No such research related to dot matrix printing has been conducted so far with forensic point of view. Thus, an attempt has been made in the present study to analyze the effect of change of substrate/paper on the printing characteristics of dot-matrix printers.

2. Materials and Methods

2.1. Collection of samples

Twenty dot-matrix printers (Table 1) and five types of substrates (or white pages) (Table 2) were selected for the study. Printouts of selected text were taken on all the five types of papers from each of the twenty dot-matrix printers. The printouts were collected in the same manner (using selected five papers from twenty dot-matrix printers) again after few days in order to observe variations in the work of printers.

2.2. Analysis of samples

The collected samples were analyzed using stereomicroscope and VSC 2000 to observe the effect of change of substrate (paper).

Table 1. Description of Printers used

Sample No.	Model No. of printer
1	Epson LQ – 1150 II
2	Epson LQ – 1150 II
3	Epson LQ – 1150 II
4	Epson LX – 300 +II
5	Epson LX – 300 +II
6	Epson LX – 300 +II
7	Epson LX – 300 +II
8	Epson LX – 300 +II
9	Epson FX – 1170
10	Wipro EX – 330 +DX
11	TVS MSP – 245
12	Wipro EX – 330 +DX
13	Panasonic – P 1694
14	FX – 2175
15	Wipro EX – 200 DX
16	Epson FX – 2175
17	Epson FX – 2175
18	Panasonic KX – 3626
19	Epson FX – 2175
20	Wipro EX – 330+ DX

Table 2. Description of types of papers used

S. No.	Type of paper	Description		Manufacturer
1	Thin	--	2.0g	--
2	Bond	85	5.3g	Bilt
3	Power	75	4.6g	Bilt
4	Image	70	4.4g	Bilt
5	Glossy	--	5.5g	De'smat

2.2.1. Stereomicroscopic studies

Samples were observed under stereomicroscope to study the following selected features of printing:

2.2.1.1. Colour: Colour of printed text on different types of papers/ substrates was observed and noted as Black (B), Dark Black (DB), Light Grey (LG), Grey (G) and Black with purple tint (B (purple tint)) (Figure 1).

2.2.1.2. Spreading of ink: Spreading of ink was observed to be present along the edges of pin impressions due to the absorbance of ink by fibres on the periphery of pin impressions (Figure 2a–b).

2.2.1.3. Lustre: It is described as an illumination from the surface of printed text that results in the glowing or shining of fibres or tiny dots when observed under stereomicroscope. The results were recorded photographically (Figure 3).

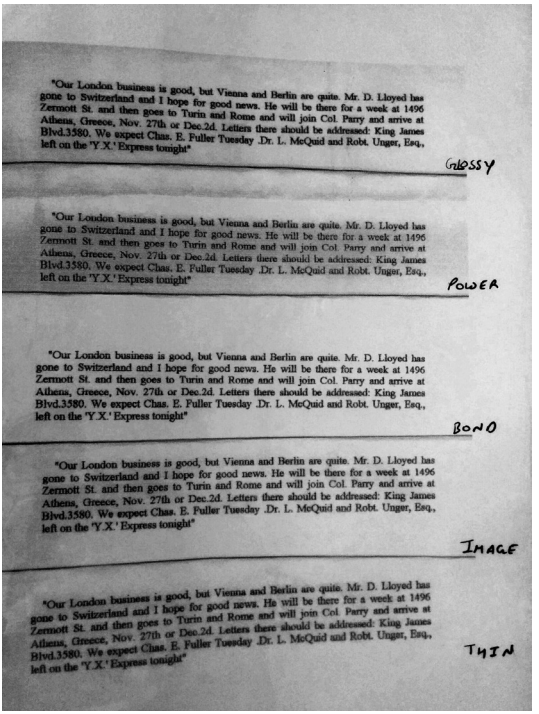

Figure 1. Colour of the printed text

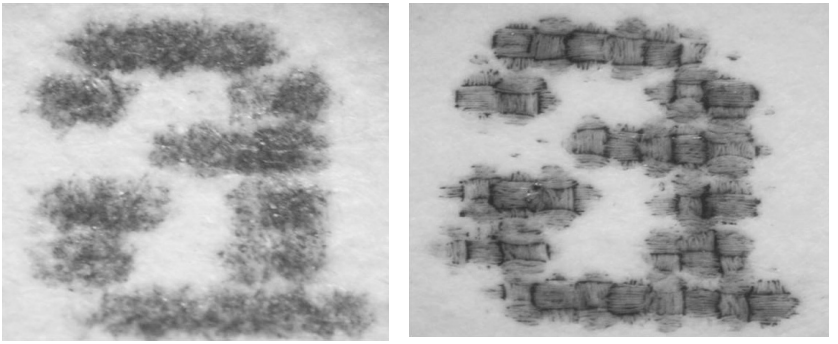

Figure 2 (a) and (b). Spreading of ink along the fibres of paper

Figure 3. Lustre on the Surface of Printed letters (Thin paper)

2.2.1.4. Impact: It is an average force with which pins strike the paper during the process of printing. The results obtained were recorded as "deep", "moderate" and "light" (Figure 4 a, b and c).

2.2.1.5. Background noise: These are small dots of ink which are present due to extra ink deposition at the edges of printed text. The results were recorded photographically (Figure 5).

2.2.1.6. Dot pattern: A number of individual dot impressions for a letter created by pins were observed. Results of observations were recorded as 'Yes' and 'No', depending upon the fact whether these could be properly counted or not (Figure 6 a–b).

Figure 4 (a), (b) and (c). Impact of pin on the paper during Printing

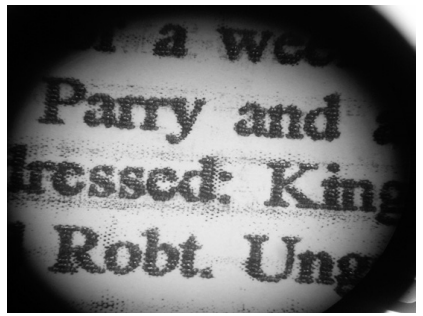

Figure 5. Background noise on Glossy Paper

Figure 6 (a) and (b). Visibility of individual dot impression on different papers

2.2.2. Video Spectral Comparator Examination:

UV fluorescence and Absorption spectra of ink of the samples were measured using Video Spectral Comparator 2000C (Foster and Freeman).

2.2.2.1. UV Fluorescence Examination: Each sample was subjected to UV Fluorescence and the results were recorded photographically (Figure 7).

2.2.2.2. Absorption Spectra: The absorption spectra of inks on the samples were generated using excitation wavelengths ranging from 400–1000 nm. For each sample, two spectra were generated and the average spectra were recorded (Figure 8a–b) using software tool in the equipment, thereby leading to more accurate absorption measurements.

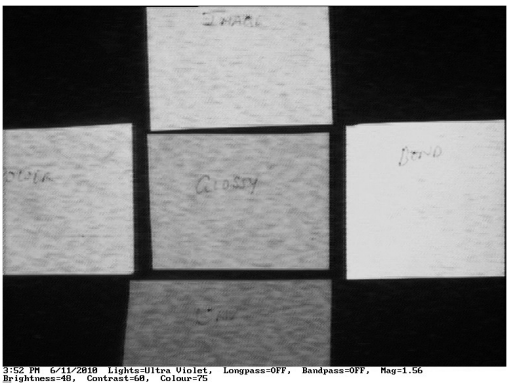

Figure 7. UV fluorescence of different paper

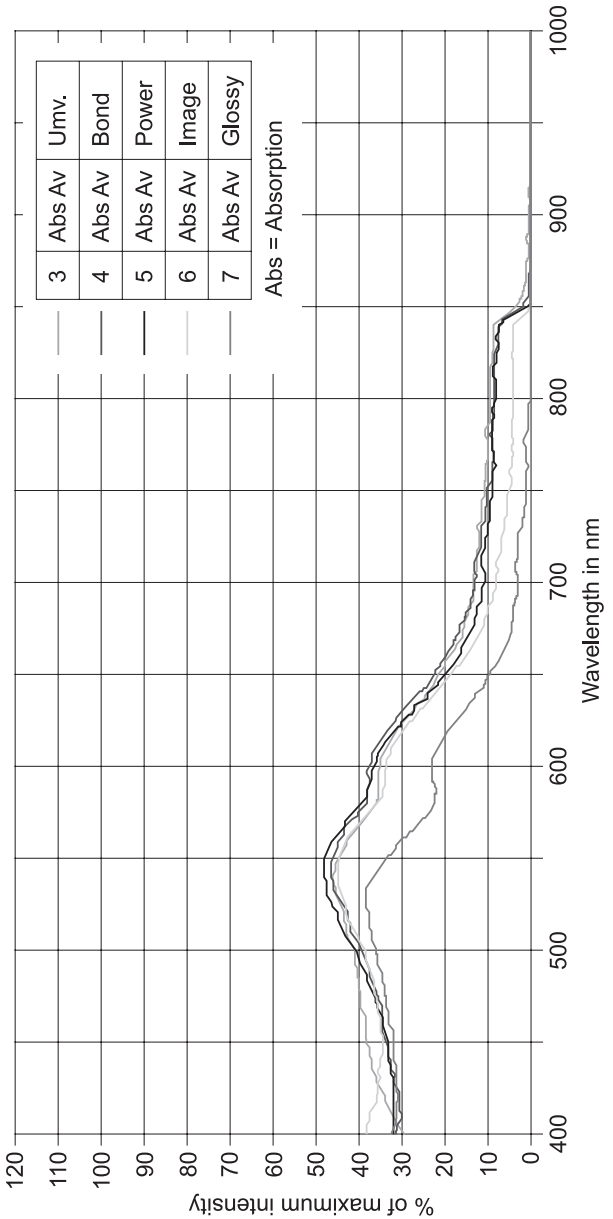

Figure 8. Absorption spectra

3. Results and Discussion

3.1. Stereomicroscopic examination

The results of above observations have been tabulated in Table 3–8.

Change in colour of printing text (ink) has been observed to be present in 85% samples (Table 3). Spreading of ink has been observed in every sample while the amount of spreading has been observed to vary with different papers (Table 4). Large spreading of ink has been observed on bond papers followed by power and image paper. Lustre has been observed to be present in every sample. However it is more in case of thin paper as compared to the rest of papers (Table 5). On the basis of impact of printing, all the twenty samples of dot-matrix printers have been classified into three groups (Table 6), samples having deep impact followed by moderate and light impact. However, no variation has been observed in case of the impact produced on different types of substrate. Ten samples of printers have shown background noise, which is described as extra ink deposits along the dot patterns of printing. But no variation in this feature has been observed with the change of the paper (Table 7). Counting of individual dots has been possible on the glossy paper only as compared to the other four types of papers (Table 8).

Table 3. Change in colour of ink with the change of substrate

Characteristics	Type of papers				
	Thin	Bond	Power	Image	Glossy
Colour	B	DB	B	B	B
	LG	G	G	G	G
	DB	DB	DB	DB	DB
	G	B	B	B	B
	DB	DB	B	DB	B (blue tint)
	G	B&G	G	G	G
	B (purple tint)	B	B	B	B (purple tint)

DB — dark black, B — black, B&G — both black and grey present, G — Grey, LG — light grey, B (purple tint) — black colour with purple tint, B (blue tint) — black colour with blue tint

Table 4. Spreading of ink on the edges of pin impressions with the change of substrate

Characteristics	Type of papers				
	Thin	Bond	Power	Image	Glossy
Spreading of ink	Y	Y***	Y**	Y*	Y
	Y	Y***	Y*	Y**	Y
	Y	Y**	Y*	Y	Y
	Y	Y	Y	Y*	Y
	Y	Y**	Y*	Y	Y
	Y*	Y***	Y**	Y	Y

Y — Yes, spreading of ink present, Y***— maximum spreading of ink,
Y** — moderate spreading of ink, Y* — less spreading of ink

Table 5. Change in the lustre of ink with change of substrate

Characteristics	Type of papers				
	Thin	Bond	Power	Image	Glossy
Lustre	Y***	Y	Y**	Y*	Y
	Y**	Y	Y*	Y	Y***
	Y*	Y	Y	Y	Y**
	Y*	Y	Y	Y	Y
	Y***	Y	Y*	Y**	Y
	Y**	Y	Y	Y*	Y
	Y***	Y*	Y**	Y*	Y
	Y***	Y*	Y***	Y**	Y
	Y**	Y	Y***	Y*	Y
	Y**	Y	Y*	Y*	Y
	Y**	Y	Y*	Y	Y
	Y	Y*	Y*	Y	Y
	Y	Y	Y	Y	Y

Y — Yes, lustre present, Y***— maximum lustre, Y** — moderate lustre,
Y* — less lustre

Table 6. Impact of printing on different substrates

Characteristics	Type of papers				
	Thin	Bond	Power	Image	Glossy
Impact	Dp.	Dp.	Dp.	Dp.	Dp.
	M	M	M	M	M
	Lt.	Lt.	Lt.	Lt.	Lt.

Dp. — deep impact, M — moderate impact, Lt. — light impact

Table 7. Background noise of printing in different types of paper

Characteristics	Type of papers				
	Thin	Bond	Power	Image	Glossy
Background Noise	Y	Y	Y	Y	Y
	N	N	N	N	N

Y — Yes, background noise observed, N — No background noise observed

Table 8. Visibility of dots used to create letter on different substrate

Characteristics	Type of papers				
	Thin	Bond	Power	Image	Glossy
Dot Counting	N	N	N	N	Y

Y— Yes, dots are countable and discernable, N — No, dots are not discernable and hence not countable

Video Spectral Comparator examination (VSC 2000C)

3.1.1. UV fluorescence examination:

Under UV light, it has been observed that all five types of papers give different fluorescence. It has been observed that the fluorescence does not change with the change of printer. So, different types of papers printed with the same printer has given different fluorescence (Figure 7).

3.1.2. Absorption Spectra:

No qualitative change in the peaks of absorption spectra has been observed with the change of substrate for a specific printer (Figure 8). Only intensity of peaks has been observed to vary with the change of

substrate. This is probably due to the fact that the intensity of absorption of light is different for different types of substrates/papers.

Results of this study illustrates that the change of substrate affects the physical characteristics in case of dot-matrix printing. However, no variation has been observed in impact of printing and background noise with the change of substrate. Similarly, only the intensity of the absorption peaks has been observed to change with the change of substrate. Laporte (2004) has discussed the effect of substrate (paper) on printed matter in case of Inkjet printer. It has been observed in the study that use of different substrates can have dramatic influence on printing. So, the study of effect of change of paper/substrate on the printed matter would definitely help examiners to give opinion upon on the cases related to the documents printed by dot-matrix printers.

4. Summary and Conclusion

The present study has been conducted to study the effect of change of substrate on printing characteristics of dot-matrix printers. Printouts taken from twenty Dot-matrix printers on five types of substrates have been examined using stereomicroscope (4x40magnification) and VSC 2000 C. It has been observed that the changes in physical characteristics with the change of substrate occur in 85% of samples. Different substrates printed from same printer have been observed to produce different fluorescence under UV light. However, no variation has been observed in impact of printing and background noise with the change of substrate. Similarly, only the intensity of absorption peaks changes with the change of substrate. So, it has been concluded that the change in substrate changes the physical characteristics of dot-matrix printing even in the same printer. These results would absolutely help the examiners to give more precise and accurate opinion on dot-matrix printouts, specifically in the examination of multiple documents (consisting of different types of papers or substrates) by avoiding errors.

References

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Summary

A study related to Dot-matrix printers has been carried out in order to analyze the effect of change of substrate on its printing characteristics. Twenty Dot-matrix printers and five types of substrates (or white pages) have been selected for the study. The printouts have been taken on all the five types of white papers from each of the twenty Dot-matrix printers. These printouts have been examined using stereomicroscope (4x40magnification) and VSC 2000 C to examine the features such as change in colour of ink, lustre of printing text, impact of printing, spreading of ink, background noise, UV fluorescence and absorption spectra. It has been concluded that the physical characteristics of dot-matrix printing gets changed by changing the type of substrate even in case of the same printer. Thus, the results of this study would definitely help the forensic document examiners to give an accurate opinion on the cases related to Dot-matrix printouts, specifically in the examination of multiple documents (consisting of different types of papers).

Keywords: dot-matrix printer, documents, printing characteristics, stereomicroscope, VSC 2000C.