

Does My Output Change with Age?

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Document examiners are often asked to determine whether multiple documents or pages of the same document were produced on the same printer or on different printers. There are several aspects of the document that can be examined in that regard. Documents produced on different laser printers can exhibit differences in the microscopic appearance of the surface of the toner printing, while documents produced on the same laser printer at the same time do not exhibit such differences. This study assesses whether there are any appreciable differences in the microscopic appearance of the surface of the toner printing produced using the same laser facsimile machine over a period of approximately 5 years. No appreciable differences were observed.

Introduction

Numerous studies have been conducted on the topic of laser printers to link multiple documents as having been printed using the same printer cartridge and/or to link documents to a particular laser printer. These studies considered such aspects of the printing as printer defects (Winter 2000), powder toner analysis (Merrill and others 1996; Trzcinska 2006), and image analysis (Mazzella 2007). This paper considers the subjective assessment of the microscopic appearance of the surface of the toner printing as a further avenue of investigation.

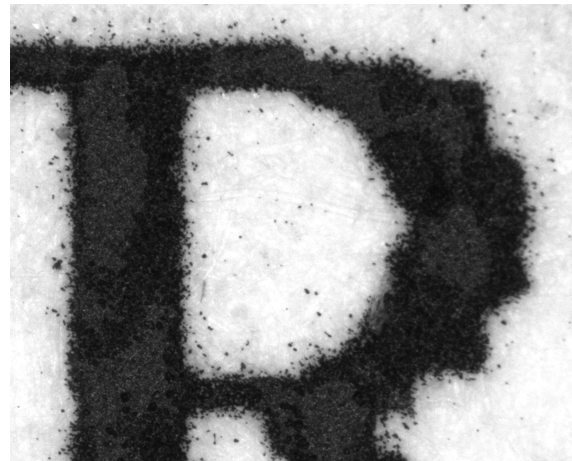
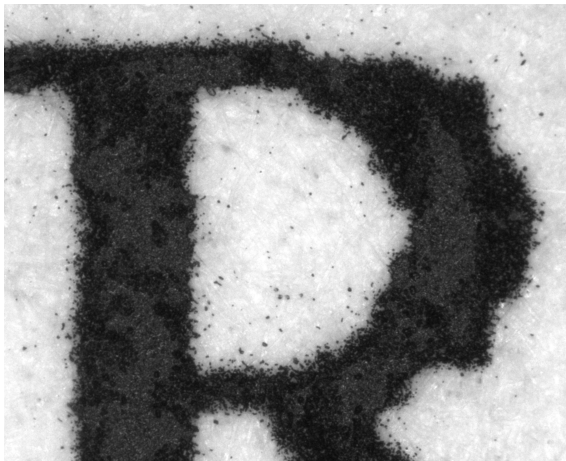
The microscopic appearance of the surface of toner printing can be different on documents produced using different laser printers, although this is not always the case. The authors observed that the microscopic appearance of the surface of toner printing did not exhibit any appreciable differences between documents produced using the same laser printer on the same occasion. The question raised was whether or not, as the machine ages, documents produced on 1 laser printer exhibited any appreciable differences in the microscopic appearance of the surface of the toner printing.

The microscopic appearance of the surface of toner printing is not uniform. The words patchy, matte, lighter, and darker can be used to describe the subjective appearance of the surface of toner printing. Sometimes the toner particles can be quite visible, giving a speckled appearance or fused together in "pools." Sometimes the fusing

of the toner can also appear to follow the pattern of the paper fibres.

The surface of toner printing can potentially be affected by the photosensitive drum; the charged roller; the charged corona wire; the laser; the composition, quality, and particle size of the toner; the fuser assembly; the print quality options (e.g., "draft," "normal," or "best"); and perhaps also the paper itself. This study did not address whether, and if so, how and to what extent, these factors may influence the surface of the toner printing. Furthermore, this study primarily considered the output of only 1 laser printer over an extended period. However, to put the study in the context of a wider sample of machines, the assessment of the microscopic appearance of the surface of the toner printing was extended to include the output from 7 other machines.

This study is useful to the field of forensic document examination in the context of assessing whether, on the basis of the appearance of the surface of the toner printing, 2 documents of different dates which purport to have been produced on the same laser printer were, in fact, produced on 1 laser printer. In the event that differences are observed in the appearance of the surface of the toner printing on the 2 documents, can that be interpreted as evidence that they were produced on different laser printers? Or is it possible that the differences are "false negatives" due to appreciable differences in the microscopic appearance of the surface of toner printing produced on the same laser printer over a period of time. As was demonstrated, it cannot be claimed that



Figures 1.1 and 1.2. Samples taken from 1 document produced using the Canon Fax L360.

documents which are not distinguished on the basis of the microscopic appearance of the surface of the toner printing thereon were necessarily produced on the 1 laser printer.

Materials and Methods

The main sample of documents consisted of facsimile transmission reports produced by a Canon (laser) Fax L360 from the time of purchase of the new machine in March 2003 until August 2008. Over that period, approximately 3,000 pages were printed. There were 2 toner cartridge changes over that period, although the dates of those changes were not recorded. No other parts of the machine have been replaced or otherwise serviced.

Isolated samples were also collected from an Epson Acu Laser C900 (printer), a Samsung SX-4521F (facsimile), a Canon iR C2620 (multi-function), a Canon iR C2880 (multi-function), a Hewlett Packard LaserJet 4 (printer), a Hewlett Packard LaserJet 5 (printer), and a Hewlett Packard LaserJet 4050N (printer).

The microscopic examination of the appearance of the surface of the toner printing was undertaken using a Leica M420 macroscope.

The microscopic appearance of the surface of the toner printing was subjectively assessed and compared. Assessments of the microscopic appearance of the surface of the toner printing were made of the following:

- a. variation within each document;
- b. variation between documents produced on the same machine; and

- c. differences between documents produced on different machines.

Results

Variation was observed in the microscopic appearance of the surface of the toner printing within any 1 document. However, this variation was relatively slight and not what would be considered suggestive of different sources. This could be referred to as "natural variation." Figures 1.1 and 1.2 are images of samples taken from 1 document produced using the Canon Fax L360. These images show the microscopic appearance of the surface of the toner printing of 2 examples of the top of the letter "R" taken from the 1 document. The surface of the toner printing in these images has an overall matte appearance which is patchy, with some areas appearing darker than others. The toner particles are more visible in the darker areas. It will be observed that this patchiness occurs in different areas on the 2 examples. Similar slight variations were observed within each of the documents examined.

Variation was observed in the microscopic appearance of the surface of the toner printing between the different documents produced using the Canon Fax L360. However, this variation was no more than the variation observed within any 1 document produced by this machine. Figures 2.1 through 2.5 are images of samples taken from documents produced using the Canon Fax L360 in the years 2004 to 2008, respectively. As described above, the surface of the toner printing in these



Figure 2.1. Sample taken from document produced using the Canon Fax L360 in 2004.



Figure 2.2. Sample taken from document produced using the Canon Fax L360 in 2005.

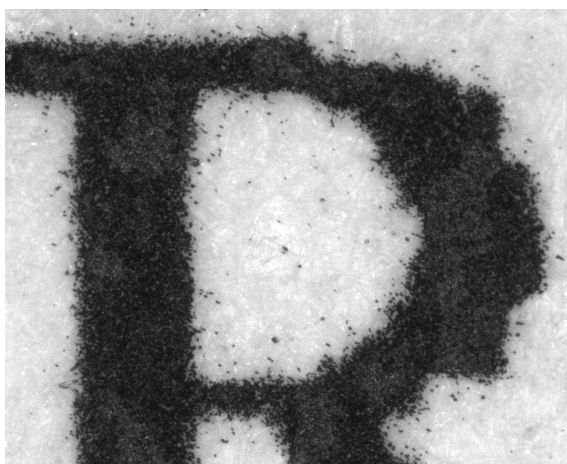


Figure 2.3. Sample taken from document produced using the Canon Fax L360 in 2006.



Figure 2.4. Sample taken from document produced using the Canon Fax L360 in 2007.

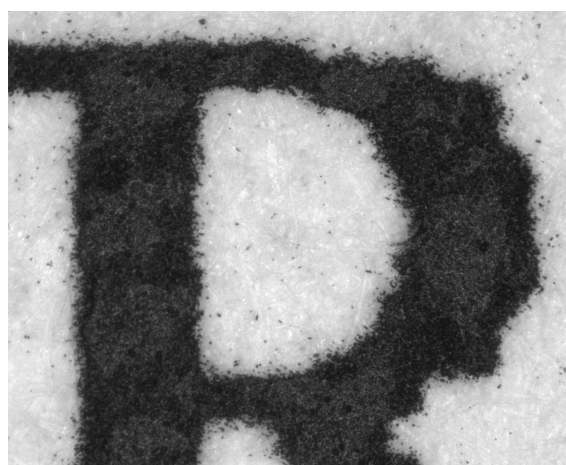


Figure 2.5. Sample taken from document produced using the Canon Fax L360 in 2008.

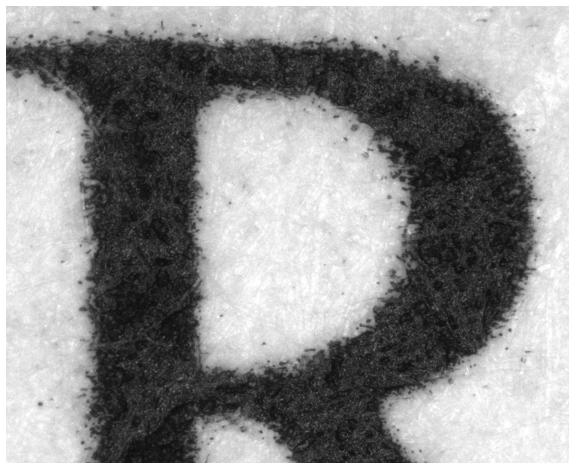


Figure 3.1. Sample taken from document produced using the Canon iR C2620.

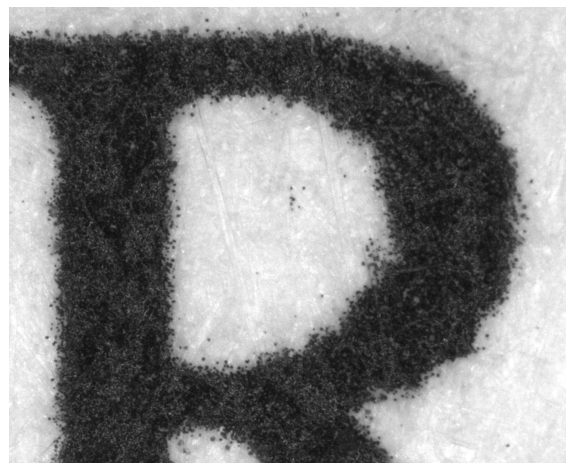


Figure 3.2. Sample taken from document produced using the Canon iR C2880.

images has an overall matte appearance which is patchy, with some areas appearing darker than others. The toner particles are more visible in the darker areas. This patchiness occurs in different areas across the 5 examples. Similar slight variations as observed between Figures 2.1 through 2.5 were also observed within and between the other documents produced using the Canon L360 Fax over the 4-year period.

Apparent differences were observed in the microscopic appearance of the surface of the toner printing between the documents produced using the Canon iR C2620 and the Canon iR C2880. However, these apparent differences were no more than the variation observed within any 1 document produced by either of these machines. Figures 3.1 and 3.2 are images of samples taken from documents produced using the Canon iR C2620 and the Canon iR C2880, respectively. Appreciable differences were observed when these were compared with documents produced on the Canon L360 Fax. The surface of the toner printing in Figures 3.1 and 3.2 exhibited smaller patches and a combination of light and dark areas which was more evenly distributed compared with the patchy appearance of Figures 1.1, 1.2 and 2.1 through 2.5. The fusing of the toner particles in some of the lighter areas appears to follow the paper fibres. Similar slight variations as observed between Figures 3.1 and 3.2 were also observed within and between the other documents produced using the Canon iR C2620 and the Canon iR C2880. This is an example where appreciable differences in the microscopic appearance of the

surface of the toner printing were not observed between documents produced using 2 different machines.

Apparent differences were observed in the microscopic appearance of the surface of the toner printing between the documents produced using the Hewlett Packard LaserJet 4, the Hewlett Packard LaserJet 5, and the Hewlett Packard LaserJet 4050N. However, these apparent differences were no more than the variation observed within any 1 document produced by each of these machines. Figures 4.1 through 4.3 are images of samples taken from documents produced using the Hewlett Packard LaserJet 4, the Hewlett Packard LaserJet 5 and the Hewlett Packard LaserJet 4050N, respectively. Appreciable differences were observed when these were compared with documents produced on the Canon L360 Fax and with documents produced using the Canon iR C2620 and Canon iR C2880. The surface of the toner printing in Figures 4.1 through 4.3 exhibited a somewhat patchy appearance, with a combination of light and dark areas, but not exhibiting as marked a definition as in Figures 1.1, 1.2 and 2.1 through 2.5. Furthermore, the toner particles in the lighter patchy areas do not appear to be as fused together in Figures 4.1 to 4.3 as they are in Figures 1.1, 1.2 and 2.1 to 2.5. Similar slight variations as observed between Figures 4.1 through 4.3 were also observed within and between the other documents produced using the Hewlett Packard LaserJet 4, the Hewlett Packard LaserJet 5 and the Hewlett Packard LaserJet 4050N. This is a further example where appreciable differences in

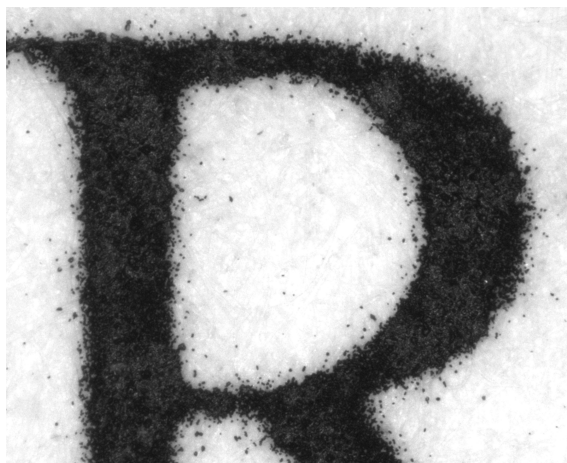


Figure 4.1. Sample taken from document produced using the Hewlett Packard LaserJet 4.

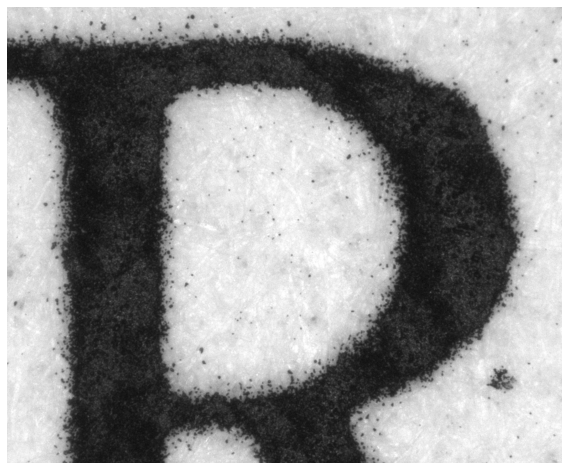


Figure 4.2. Sample taken from document produced using the Hewlett Packard LaserJet 5.

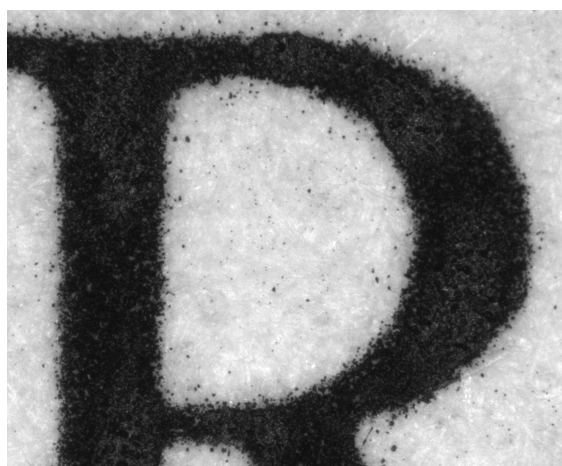


Figure 4.3. Sample taken from document produced using the Hewlett Packard LaserJet 4050N.

the microscopic appearance of the surface of the toner printing were not observed between documents produced using 2 different machines.

Significant differences were observed in the microscopic appearance of the surface of the toner printing between the documents produced using the Epson Acu Laser C900, the Samsung SX-4521F, the Canon Fax L360, the 2 Canon iR machines (collectively) and the 3 Hewlett Packard machines (collectively). Figures 5.1 through 5.5 are images of samples taken from documents produced using the Epson Acu Laser C900, the Samsung SX-4521F, the Canon Fax L360, the Canon iRC2620 and Hewlett Packard LaserJet 4050N, respectively. Figure 5.1 depicts a sample

from the Epson Acu Laser C900 which showed an overall matte appearance with relatively small dark patchy areas, with the lighter patches appearing to follow the lines of the paper fibres producing angular shapes. Figure 5.2 depicts a sample from the Samsung SX-4521F which showed an overall matte appearance with reasonably well defined patchy areas with a greater concentration of dark areas than light. The Canon Fax L360 (Figure 5.3), the Canon iRC2620 (Figure 5.4) and Hewlett Packard LaserJet 4050N (Figure 5.5) images have been described previously. Appreciable differences were observed between the microscopic appearance of the surface of the toner printing on documents produced using these 5 machines.

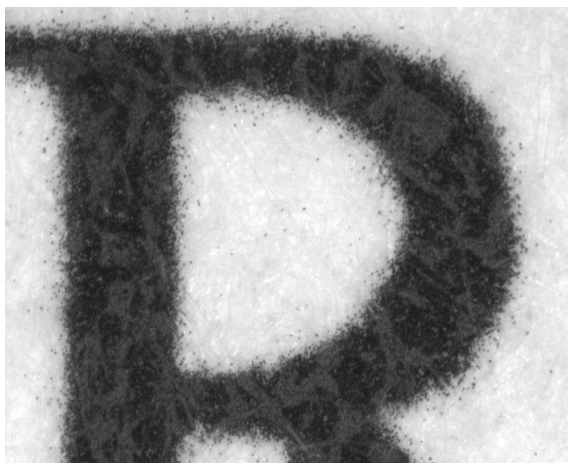


Figure 5.1. Sample taken from document produced using the Epson Acu Laser C900.

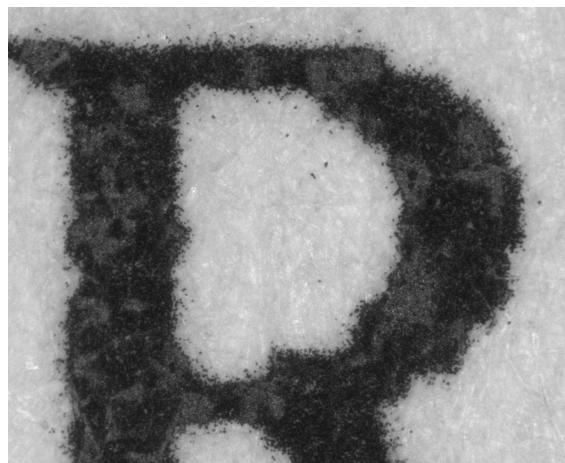


Figure 5.2. Sample taken from document produced using the Samsung SX-4521F.

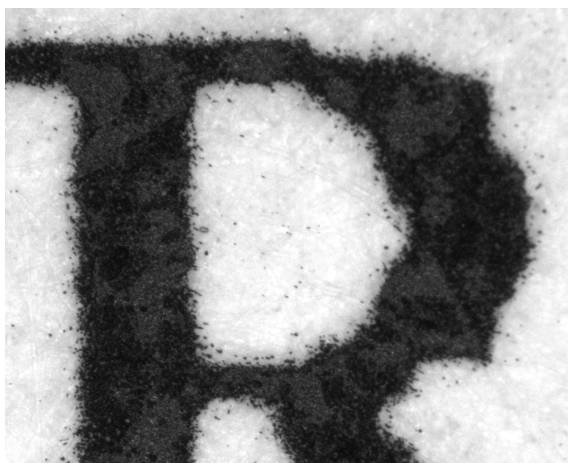


Figure 5.3. Sample taken from document produced using the Canon Fax L360.

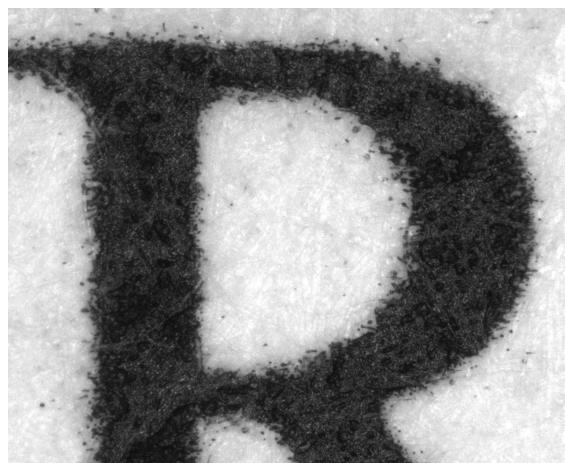


Figure 5.4. Sample taken from document produced using the Canon iRC2620.

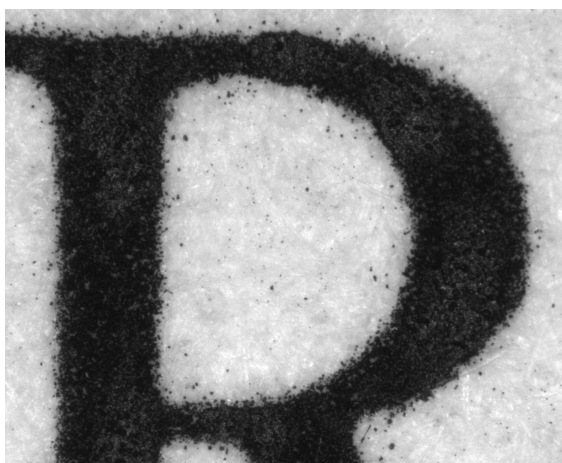


Figure 5.5. Sample taken from document produced using the Hewlett Packard LaserJet 4050N.

Please note, it is important to concentrate on the appearance of the surface of the toner printing in these images and not to take account of the detailed shapes/outlines of the letters "R."

Conclusions

This study found that, notwithstanding the 5-year period, there were no appreciable differences in the microscopic appearance of the surface of the toner printing produced using the Canon Fax L360.

In general, no appreciable differences were observed in the microscopic appearance of the surface of the toner printing between documents produced on machines of a similar make, although differences were observed between the Canon Fax L360 when compared with the 2 Canon iR machines.

Appreciable differences were observed in the microscopic appearance of the surface of the toner printing between documents produced on machines of different makes.

As with comparative examinations of inks undertaken using the VSC or similar instrument, the examination of the surface of toner printing can be used for discrimination, not identification. Similarities observed between the microscopic appearance of the surface of the toner printing on 2 documents do not necessarily mean that they were produced using 1 machine, as demonstrated above with the 2 Canon iR machines and also demonstrated with the 3 Hewlett Packard machines. Significant differences were found, however, in the microscopic appearance of the surface of the toner printing between documents produced using machines of different makes (in a limited survey of different products).

In a casework situation, an examination of the microscopic appearance of the surface of the toner printing could be an additional tool in addressing issues of whether or not the same laser printer was used to produce multiple documents over a short period or extended period of time and whether or not multiple documents were produced on different laser printers. Furthermore, such an examination could be an additional tool in addressing whether there is evidence from the toner appearance of page substitutions or of word or paragraph insertions.

This study should be extended to a wider sample of machines to assess differences between documents produced over a period of time, machines which have been serviced more often and/or have had more parts replaced, a wider sample of machines incorporating different makes and

models, and testing the effect of different paper on the microscopic appearance of the surface of toner printing.

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