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Tech Bulletin

Page Yield of Printer Cartridges

Dr. John Wyhof, Technical Director, Static Control Components, Inc.

Introduction

Toner usage, or page yield, information is often required by the cartridge remanufacturer. Concerned users, government agencies and corporate purchasing agents need to know the cost per print as they are often purchasing the remanufactured cartridge to save money. It is the responsibility of the remanufacturer to determine and provide this information. The page yield for a specific printer cartridge is controlled by the print coverage on the page, the amount of usable toner supplied, the OPC properties, the toner properties, and the development system.

Toner Usage Defined

Toner usage is the weight of toner consumed during the printing of one page that has a specified coverage of text and/or graphics. The coverage is specified by the ratio of black to white area on the printable area of a page. All of the toner that is consumed at the development step will not appear on the page. The toner usage per page can be used to calculate the page yield for a given weight of toner.

Parameters Affecting Usage

The active components in the first two steps of the electrophotographic process determine the toner usage. During the exposure step the light sensitivity (hotness or coolness) of the OPC will determine the size of the spot discharged by the laser beam. At the second step the toner, the magnetic roller sleeve, doctor blade, and bias voltages will determine the amount of toner used for development of the discharged area on the drum. Toner usage is not affected by any of the electrophotographic process steps to follow, i.e. transfer, fusing, and cleaning. Transfer efficiency does not affect the toner usage.

Critical Parameter: Printed Dot Size

The laser printer image is produced by a combinations of black dots on the page. A black dot can be printed at any pixel location. The pixel is the smallest area which can be printed or not printed depending on the image data. The number and size of pixels are determined by the "resolution" of the printer, usually as the number dots per inch (dpi). For a 300 dot per inch (300 dpi) printer the center of each pixel is located 1/300" (84.6 µm) from the center of the nearest pixel. The pixel size is 1/300" (84.6 µm) in diameter.

The actual printed dot for a printer is usually 25% to 75% larger than the laser dot pixel size. If a cartridge is remanufactured with a "hotter" drum the dot size will expand. With a very hot drum the laser dot size may be 2 to 3 times larger than the pixel size. The oversized dots on the edges of text characters will expand the character size. But the oversized dots in the middle of a solid black area or larger font character will have no real effect. Therefore, differences in OPC light sensitivity will affect toner usage in text printing, but have relatively little affect on toner usage when large solid areas are printed.

...the light sensitivity (hotness or coolness) of the OPC will determine the size of the spot discharged by the laser beam.

As shown below, the text print will change area of coverage.

The higher sensitivity, "hot", OPC drums will have an increased discharge area. During development, toner will be attracted to an expanded area and use additional toner. High resolution "cooler" OPC drums will maintain the edge definition. These are usually used by the OEM. Over the past few years cartridge remanufacturers have enjoyed an expanding market using these "hot" drums. The user perceives these prints as "darker" with a higher contrast image. However, there is a corresponding reduction in page yield and resolution.

Experimental Technique

Measurement techniques for determining toner usage are well known. The weight of the toner in the hopper is measured at the start and end of the test. The total page count for the test is recorded. If the transfer efficiency is also measured, the weight of the toner in the waste bin must also be measured at the start and end of the test. Many printers have specific adjustments for density, or contrast, as well as, resolution enhancement and toner saver features. These settings must be known and recorded when the toner usage is measured. For example, the toner saver feature on the Hewlett Packard® 4V can reduce the usage by more than 60% on text printing, making a cycle more than twice its normal pages.

The toner usage is calculated and reported as the number of milligrams of toner per page (mg/page) used based on the weights measured. For 5% page coverage this value is normally in the range of 40-70 mg/page for Canon® engine printers. A very "hot" aftermarket drum used in a Canon SX printer may result in over 90 mg/page. The following table shows the calculated OEM usage based on the published page yield from the printer manufacturer. The last column shows the wide range of toner usage observed for remaufactured cartridges with a variety of toner and OPC combinations.

Cartridge Type	Normal Toner Load	Published OEM Page Yield 5% Coverage	OEM Calculated Usage per page	Remanfactured Toner Usage per page
SX	275 g	4000 pages	69 mg	45-90 mg
LX	225 g	3500 pages	64 mg	45-90 mg
NX	470 g	10000 pages	47 mg	40-80 mg
EX	350 g	6800 pages	51 mg	35-80 mg
BX	400 g	8100 pages	49 mg	35-85 mg
WX	840 g	15000 pages	56 mg	45-85 mg
PX	160 g	3000 pages	53 mg	45-65 mg
VX	220 g	4000 pages	55 mg	45-65 mg
AX	140 g	2500 pages	56 mg	45-60 mg

Non-magnetic toner based cartridges, such as the IBM/Lexmark printer cartridge, will have relatively low toner per page usage as there is no iron oxide in the toner making the particles weigh less.

Measurement of Toner Usage

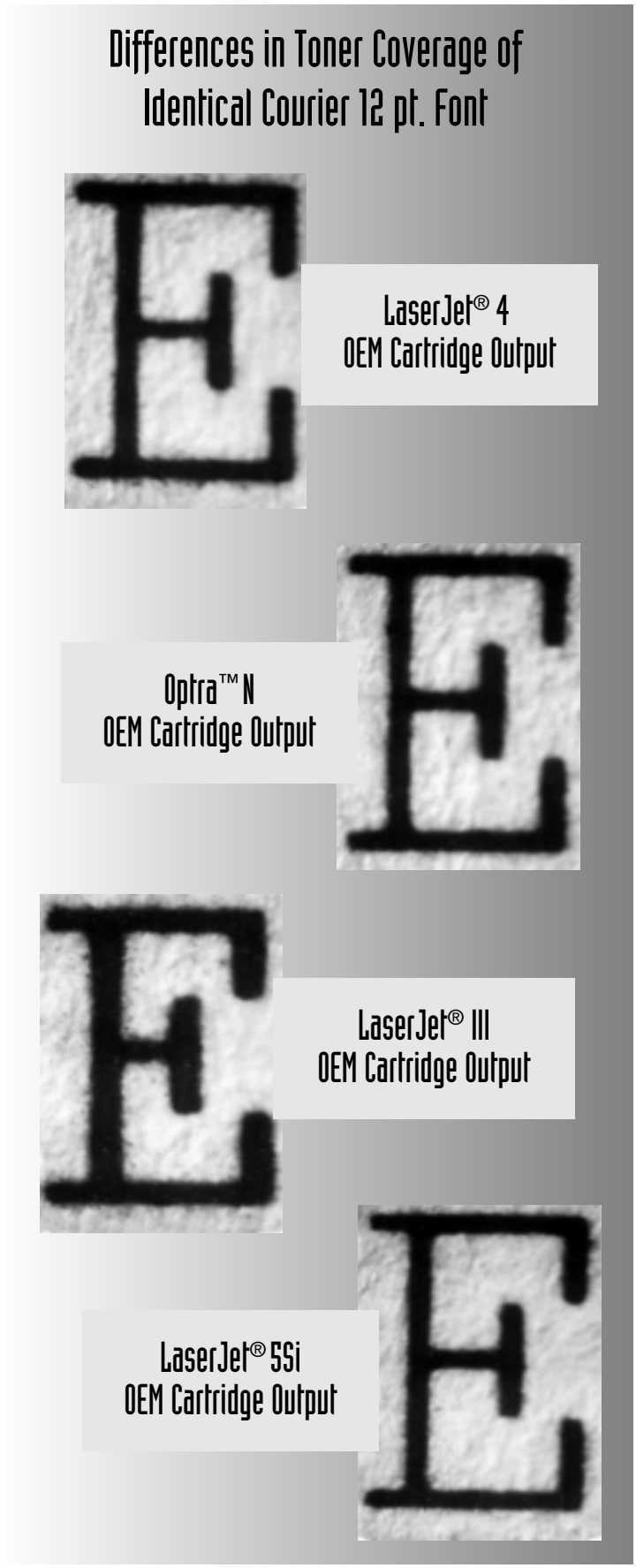
The toner consumed must be measured accurately to give meaningful results. If the starting and ending weights of the toner are determined with an electronic scale with ±0.5 gram accuracy, then 1000 pages would be required for the results to be within ±1%.

The page yield per gram of toner is easily calculated from the toner usage. The actual page yield of the "cartridge cycle" may be less since all of the toner in the hopper cannot be used for printing. The cartridge cycle end is defined by the initial "toner low" signal or "toner low" signal after one shake.

The Test Target and Experimental Technique

The page yield of the cartridge is quoted by the printer manufacturer for the specific printer and model. The de facto standard test target is a page of text with 5% coverage of the printable area. This printable area is defined at 8" x 10" for 8.5" x 11" paper since most printers and application software do not normally print on the 1/4" on each side of the page or at the 1/2" at the top and bottom of the page.

The text font must be available on all printers using the cartridge. One method is to create the text using 12 point Courier with the same character or a variety of characters spread over the print area of the page. The Courier font is selected as it is a printer font available on most desktop printers. The print coverage is determined by measurement with an optical scanner and software which has the capability to count the black pixels or area actually printed. The OEM cartridge can be used as the base line target as the end user will be comparing the OEM to a remanufactured product. Different print engines or families of print engines will require a different number of the identical Courier characters, such as the letter "E", to achieve an accurate 5% coverage target, see figure below. In some cases, the print characteristics of the OEM cartridge may no longer be desirable and the 5% target can be determined by a "standard" remanufactured cartridge. In this manner a direct comparison can be done with any other remanufactured cartridge.



The weight of the toner in the hopper is measured at the start and end of the test. The total page count for the test is recorded. Many printers have specific adjustments for density, or contrast, as well as resolution enhancement and toner saver features. The settings must be recorded so that comparison tests will be correct.

Cartridge Component Effects on Toner Usage

It is difficult to separate all of the effects on the toner usage as they are simultaneous interactions taking place. The strongest effects have been identified here for simplicity. The remanufacturer can adjust components for maximum yield.

As discussed earlier, the light sensitivity of the OPC will strongly affect the size of the discharged area on the drum and therefore the toner usage. The charge on the toner particles, toner particle size, the development bias voltage and the conditions of the developer sleeve will affect the number of toner particles attracted to discharged areas of the OPC. The condition of the developer sleeve will affect the transfer of toner particles from the sleeve to the OPC.

A worn developer roller can inhibit the transfer of toner to the OPC. It can control the size and charge on the particles that get transferred to the OPC. The original developer roller will wear usually first in high use print areas. A “resurfaced” or “coated” developer sleeve can increase the release of toner to the OPC. This can increase the print density, as well as the toner usage.

Conclusion

The choice of OPC, toner and development components will determine the print appearance and page yield for the cartridge. Understanding how these work and interact is critical to the remanufacturer of high quality cartridges.

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