MICR Performance and the Relationship to MICR Toner Adhesion

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Abstract

MICR laser non-impact printing technology, when used for commercial check printing, demands a higher level of performance than its non-MICR printing counterpart. Toner adhesion to the receiver that would be acceptable in a standard document would not be acceptable in the MICR world because of the mechanical abrasion that the document is exposed to during check post processing. Image characteristics must not only be visually aesthetic but also have the magnetic characteristics necessary to be read by the high-speed readers that are commercially in place. This paper reports the development of a metric using a time-tested method of measuring toner adhesion, namely the tape transfer test. This metric relates the results of this tape test to actual performance characteristics as determined by calibrated MICR readers. The metric can be used as a reproducible response variable for relating process control variables to toner adhesion. The actual fundamental modes of adhesion failure are also discussed.

Introduction

MICR check printing standards were established and implemented in the late 1950's and early 1960's.[1] The standards and practices were based on the, then, well-known impact printing technology. In this same time period Xerox was introducing electrophotographic technology into the world of office copying. With the development of the digitally addressable optical write heads (Laser scanners, LEDs), xerography became the technology of choice for fast, high quality printers. Laser printers, as they are often referred, fall into a class of non-impact printers of which ink-jet, dye-sublimation and other technologies belong.

With further technological developments of magnetic dry ink (magnetic toner), once again by Xerox, non-impact MICR printing was born in the mid 80's. Other laser printer manufacturers quickly followed suit with their own versions of MICR printers. Mono-component MICR toners were developed for use in the lower speed printers (50ppm or less).

MICR laser printing had to comply with the "ANSI X-9 Accredited Standards Committee" specifications on character formation and signal strength. Because of the nature of the xerographic process a host of other issues directed at meeting the standards became apparent. This paper reports the development of a metric for the measurement of toner adhesion to the receiver and the role it can play in the dialog that must occur between the printer manufacturer and the toner manufacturer. The issue of adhesion and related bank failures is only brushed on by the X-9.27 standard.[2]

Current Status

The factors that affect toner adhesion to a receiver are many and its importance is dependent on the final demand on the print. Office printers, where visual aesthetics are most important, often times must fail for adhesion miserably before the issue is brought before the service personnel. In MICR printing, adhesion failures can and do result in an inability to read the document in a high-speed reader-sorter. Although this has been a documented problem the measurement of toner adhesion has, at best, been a subjective observation. More importantly there is a lack of recorded correlation between the various methods used to evaluate adhesion and the actual results obtained from the various reader sorters.

The adhesion standards that are adopted by an organization are usually internal, and are adapted to meet the specific criteria predicated by the final use of the document. This approach works well when the process that controls the output is also internal. Many niche businesses today are forming partnerships with other niche business to produce a product or products that are a combination of each ones expertise. This is truly the case in MICR printing where the printer manufacturer is generally distinct or distanced from the mainstream toner manufacturer. To this end a standard that generates a realistic adhesion metric is needed, if for no other reason, to provide a common ground for communication between manufacturers. "What is good enough" is not as important as the mutual agreement on a crossover measurement technique. The argument from there can be "what is good enough".

Adhesion Failure

Printed MICR characters must meet the ANSI standard for magnetic signal strength and character integrity. The specification is clear enough to determine what degradation can be tolerated before the character is termed unrecognizable. This paper is aimed at using the measurement of this specification to determine the impact of adhesion failure.

Toner adhesion failure on a MICR document may be manifested in a number of ways, but the phenomenon can be reduced to adhesive failure, cohesive failure, or a combination. Cohesive failure, or separation within the toner stack, may reduce the amount toner in the image uniformly, resulting in a density reduction, which in the case of MICR applications will result in a signal strength reduction. Adhesive and cohesive failures can combine to create voids, edge defects, or smear, resulting in both low MICR level and unrecognized characters (*Figure 1)*.

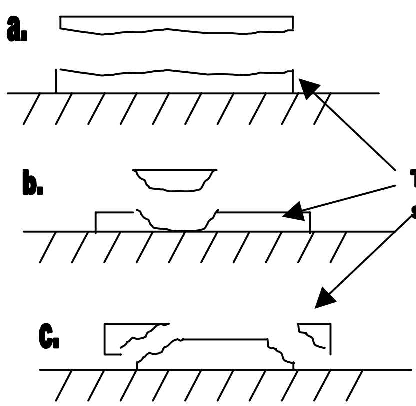

Figure 1. Examples of: a) Cohesive failure, b) Adhesive Failure, and c) Edge degradation due to either or both.

The figures of merit that must be maintained for laser printed MICR characters are signal strength and character integrity, both directly after printing and after a reasonable amount of time and handling. Signal strength is primarily determined by the toner formulation and print density, while adhesion/cohesion is strongly dependent on fusing characteristics for a given toner and paper. This paper focuses on the latter.

Experimental

In the earlier phase of this work a comparison was made between the various methods of adhesion testing and fusing parameters. Crack testing, perhaps the most popular for visual grading, rub testing, scratch testing, and tape transfer were all compared. It was determined that tape transfer gave the largest latitude and finest gradation for this particular effort. The tape transfer was also the most forgiving technique. In other words essentially the same result would be realized using different tapes from different manufacturers applied with different techniques. The ultimate goal was to devise a quick but accurate method for determining the level of adhesion for comparative purposes.

The tape that was used for the tape transfer in this work was Highland® Brand 6200 Invisible Tape. For the testing that is described, the tape is applied to a printed MICR line with finger pressure high enough to insure proper contact with the toner and paper and remove any air bubbles. The tape is then stripped by peeling at an angle. The angle of peel is not critical, but this technique reduces the number of instances where the paper cohesion fails, eliminating the utility of the test. As the tape is peeled any toner and, or paper that adheres to the tape rather than the paper will be removed with it. The tape with the residual material is then applied to another sheet of white paper. The residual on the tape and the residual MICR line can then be analyzed by comparing the before and after results of the tape transfer.

Three criteria were used to evaluate the results of the tape test: a) a visual scale of 1 to 10 with 10 being best, b) the average MICR level of the MICR line before and after the tape transfer, and c) the degradation in the characters in comparison to the ANSI standard. To make the comparisons in b) and c) the MICR line was read before and after the tape transfer with an RDM® GT MICR Qualifier. This instrument is designed to measure the MICR level of each character and its adherence to the ANSI standard.

Different levels of adhesion were produced experimentally by varying the temperature at which the MICR line was fused. To do this an IBM Info-Print 20 printer was modified such that the fusing temperature could be precisely controlled by varying the duty cycle of the heating lamps. The fusing temperature was monitored and measured with a type K thermocouple mounted in contact with the fuser roller in the paper path. 20 pound xerographic DP Quick Copy paper manufactured by Weyerhaeuser® along with various MICR toners, designed for this printer, were used for these experiments.

Although the data that are presented here focus on toner adhesion to 20# xerographic bond paper in conjunction with the IBM Info-Print 20 printer fuser configuration, the technique and general result are applicable to most other printers, as well as other papers. Each, of course, must be evaluated on their own merit.

Results

As with all toners, many properties of the polymer blend that form the toner must come together to provide adequate performance. MICR conversion must take into account that the MICR toner must adhere to the given receiver within the fusing latitude of the standard printer.

When tape is applied to a MICR line that has not been adequately fused and then stripped the result is that portions of the character are removed. Figure 2 illustrates how a character can change as a function of adhesion before and after the tape is applied and removed.

The illustration shows that the major failure mode with this type of test is adhesion failure at the toner/ paper interface. The forces on the toner and paper as the tape is being stripped are both normal and tangential to the toner/paper plane. An argument can be made that if the toner does not sinter properly and if the temperature is not hot enough to allow the toner to flow around the paper fiber, this type of failure would result. The failure would initiate at the weakness at the interface and propagate through the toner stack at the weakest boundary. This result is a characteristic of both standard toner and MICR toner. Sanders and Rutland have investigated toner adhesion to paper as a function of paper surface energy and concluded that the toner must also wet the paper to allow flow to improve adhesion.[3]

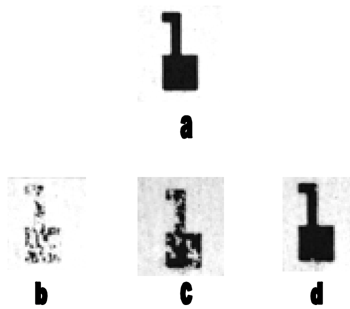

Figure 2. The result of stripping a MICR character with tape: a) The original character, b) portion remaining poor adhesion, c) medium adhesion, and d) good adhesion.

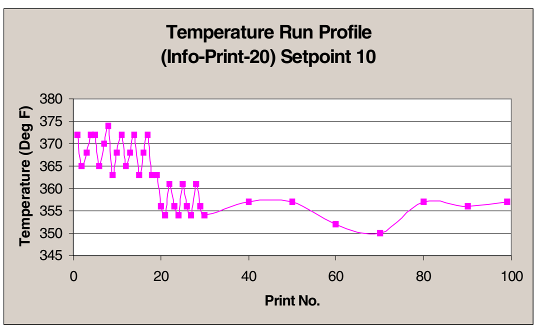

Figure 3. Typical temperature profile of an IBM Info-Print 20 printer at a fuser setting just past midpoint in its range.

Each printer has a predetermined fuser temperature profile. Figure 3 illustrates the fuser temperature profile of the IBM Info Print 20 printer from startup to continuous run, at a fuser setting of 10, out of choices from 1 to 15. The user, through the machine control logic, determines the temperature range and hence the profile that the printer will run. It is essential to understand this characteristic when converting a printer designed for standard toner to a MICR printer, as this determines the fusing latitude available at a given set-point.

The focus of this effort is to correlate the adhesion failures, such as are shown in figure 2, which can result from poor fusing and other causes, with the degradation in MICR performance. Figure 4 shows the relationship between fusing temperature and the visual quality of the MICR line after a tape transfer. Figure 5 is a comparison of the MICR signal strength before and after the tape transfer, as determined by the RDM GT qualifier. Figure 6 shows the increase in the number of bad characters in a MICR line after the tape transfer, determined by the same reader.

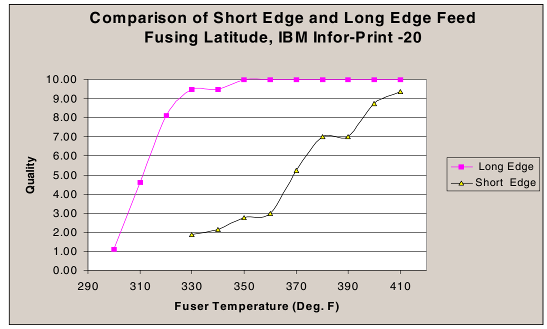

Figure 4. Adhesion quality index (1 –10) as a function of fuser temperature. ■ *MICR line near paper edge of long edge feed.* ▲ *MICR line near trailing edge of short edge feed.*

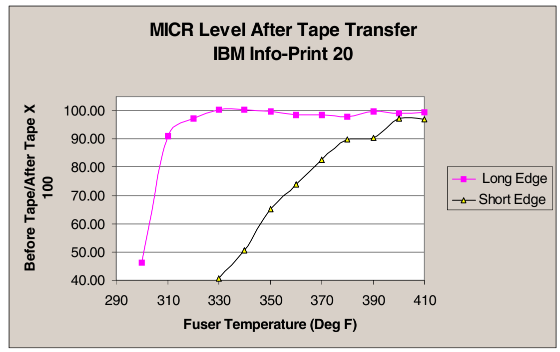

Figure 5. MICR signal level after tape transfer. Legend same as above.

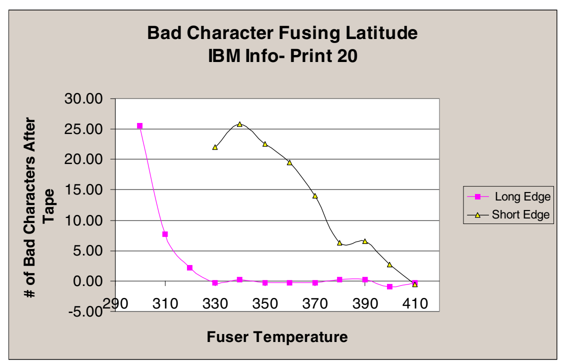

Figure 6. Increase in the number of bad characters after tape transfer. Legend same as above.

In each of figures 4, 5, and 6 the two lines on each plot correspond to location of the MICR line with respect to the direction of paper feed, illustrated in figure 7.

When the MICR line is located at the middle trail edge of the paper, as in the image on the left in figure 7, the energy delivered to the toner is lower because of the drain from the area of the sheet that has passed before. The actual local temperature that the toner and paper experience can not be easily measured but can be visualized by the reduced fusing latitude. Conversely, when the MICR line is located near the edge of the paper, as in long edge feed, the toner can draw energy from the adjacent area of the fuser roller that has not been drained. The difference in performance by MICR line placement can be quite remarkable.

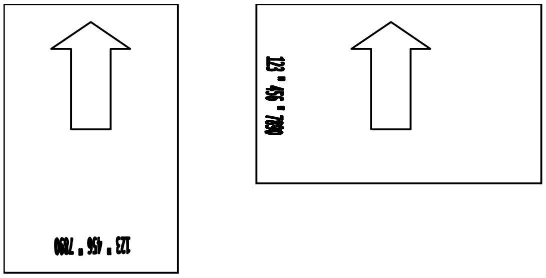

Figure 7. Location of MICR line in short edge feed (left), and long edge feed (right).

Discussion

Quantifying toner adhesion to paper, as has been demonstrated in this treatise, is quite an easy task, when compared to the task of trying to relate all of the variables that can have impact on adhesion to final performance. Reader/sorter tests should always be performed as the final test of performance criteria but correlating them with every combination of circumstances would be nearly impossible. Producing a toner that would also deliver adequate results over all circumstances would be just as impossible.

The techniques that are discussed can, however, be used as a screening tool to discern differences between a given combination of variables and baseline performance. They can also be used as a common reference in the dialogue that occurs between vendors as well as vendors and end users.

Conclusion

A method for quantifying and comparing the impact that adhesion will have on MICR performance has been proposed and demonstrated. A direct relation between this method and actual performance in a reader/sorter has not been made for this technique, or for that matter, any other. The technique is valuable because it allows fine scale, reproducible results for comparing relative MICR toner adhesion performance.

References

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Biography

James C. Maher received his B.S. in Physics from the University of Rochester and M.S. Electrical Engineering from the University of Rochester. He has 35 years of experience in the reprographics, and data storage industry. Corporate experience; Xerox Corp. 16 years, Eastman Kodak/Nexpress, 17 years, Storage Technology Corporation, 2 years. He is currently with Rosetta Technologies Corporation, Tampa, FL.