J15 Assessing the Impacts of Induction Spatial Effects on Magnetic Flux Measurements of Toners

Carrie Polston, BA, Sam Houston State University, Huntsville, TX 77341; David E. Thompson, PhD, Sam Houston State University, Department of Chemistry, Huntsville, TX 77341; Patrick Buzzini, PhD, Sam Houston State University, Huntsville, TX 77340*

Learning Overview: After attending this presentation, attendees will understand: (1) the potential for the use of a quantitative magnetic flux measuring device to differentiate between black-and-white toner-printed documents from different sources, and (2) the magnetic characteristics exhibited by toner printed documents and how to employ magnetic flux measurement techniques during comparative examinations between questioned and reference printed texts.

Impact on the Forensic Science Community: This presentation will impact the forensic science community by providing a method for quickly screening black-and-white toner-printed documents, reducing the need for more time-consuming or destructive methodology.

This study expands on questions raised by previous research into magnetic properties of toner. Specifically, this research investigates the effects of the external biasing unit on the repeatability of magnetic flux measurements of toner-printed documents. The hypotheses advanced were that: (1) the sample does not reach saturation magnetization for all particles if the sample distribution is abnormally shaped and the surface area of the toner exposed to the induction current is less than one-fourth of the total sample surface area, and (2) hysteresis effects can enhance or suppress the native magnetic flux of the sample depending on the sensor orientation relative to the native flux field of the sample. Both phenomena could lead to aberrant measurement values which are not representative of the true value for the sample and can increase the apparent sample inhomogeneity and measurement uncertainty if not controlled.

To test these hypotheses, measurements were conducted on five samples collected from different printing devices. The samples were printed with controlled grids of square, rectangular, and elongated rectangular blocks that all had the same area as well as line grids of differing densities. Thirty measurements were conducted on each sample and on each grid type, with the sensor oriented so the rectangles or lines were parallel to the induction current. The measurements were repeated in planes of rotation of 90°, 180°, and 270° counter to this original position. The values obtained for each sample in the different planes of rotation for the square grid were compared with a *t*-test to evaluate the presence and impact of hysteresis effects. The values obtained for each sample in the different planes of rotation for the rectangular grids were compared to those obtained for the square grids using the *t*-test to determine the impact of the induction current orientation effects.

It was found that both hysteresis and induction current orientation effects had a significant effect on the results obtained when comparing the measurements taken from one sensor orientation to those taken from another orientation (p value <.01). However, the magnitude of the hysteresis effects was smaller (<20% enhancement or suppression) than the magnitude of the induction orientation effects (up to 90% suppression). The hysteresis effects were also found to be reciprocal, with enhancement values mirrored by equal and opposite suppression values in another plane of orientation. This indicates that the hysteresis effects can be controlled via sampling methodology. New quantitative methods are needed to anticipate and correct for orientation-induced variation in the measured magnetic flux. Important inputs for such methods will include the surface area of the toner and its orientation relative to the induction current.

These findings have identified orientation effects as a significant source of variability in magnetic flux data and the need for new quantitative models that correct for this variability. The ability to recognize and correct for orientation-induced variations will be critical to the future implementation of a method using magnetic flux measurements in forensic laboratory settings, where there is a need for rapid, non-destructive screening of toner-printed documents.

Questioned Documents, Toner, Magnetic Flux