B168 Modeling Firearm Tool Mark Persistence Through Objective Surface Metrology and Analysis

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After attending this presentation, attendees will better understand how firearm tool marks persist over many firings. Attendees will also learn the basics of 3D measurements and analysis using the cross-correlation function as well as standard surface texture parameters.

This presentation will impact the forensic science community by providing objective support for the reproducibility of firearm tool marks over many firings. This research builds upon previous research in which examiners were able to visually identify the first test fire against the rest of the persistence test fires. This presentation will also provide quantitative analysis of how the marking surface is changing over time.

The study objective is to quantify the microscopic changes to the marking surfaces of a firearm (land, breech face, and firing pin) and how these changes affect the reproducibility of the generated tool marks on bullets and cartridge cases. The 2008 Ballistics Imaging report stated, "The validity of the fundamental assumptions of uniqueness and reproducibility of firearms-related tool marks has not yet been fully demonstrated."[1] The report also state, "A designed program of experiments covering a full range of sources of variability is important to test the fundamental assumptions, as well as to better document phenomena like "settle-in" effects." [1] Previous research has been conducted to evaluate the level of persistence seen on firearm tool marks using visual comparisons of test fires throughout the lifetime of the firearm.[2,3] These studies have concluded that examiners are able to visually identify Test Fire 1 with the rest of the persistence sets. They also noticed wear over time and slight changes to the tool marks created.

The current research seeks to provide more objective measurement and analysis to quantify how the tool marks are changing over time. The degree of similarity between bullets and cartridge cases are evaluated using the maximum value of the normalized Cross Correlation Function (CCF) or Areal Cross Correlation Function (ACCF). To quantify the physical changes of the tool marks, standard surface texture parameters found in the American Society of Mechanical Engineers (ASME) B46.1-2009 are used.[4] These include arithmetic mean deviation of the assessed profile/surface (Ra, Sa), root mean square deviation of the assessed profile/surface (Rq, Sq), maximum profile peak height (Rp, Sp), maximum profile valley depth (Rv, Sv), and total height of the profile (Rt, St). The test fires used in this research were generated by the following groups: (1) Alameda County Sheriff's Office Crime Lab. Two thousand bullets and cartridge cases fired from a new Ruger® P89 pistol. The first ten, then every 25th, test fire was collected; (2) Indiana State Police Laboratory. Ten thousand bullets and cartridge cases fired from three new Beretta® 96G pistols. First three, then three more test fires at 500-round intervals were collected.

Measurements were taken with a disc-scanning confocal microscope which generates 3D topographic data. A 10X objective with 0.3NA was used for breechface measurements and a 20X objective with 0.6NA was used for firing pin and bullet measurements. Standard Gaussian filters were applied to extract the pertinent individual tool marks used for identifications. Several experiments were conducted to show the trend in CCF/ACCF and surface texture parameters over the test fire sequences. This research helps to provide more objective analysis of firearm persistence as well as evaluate the reproducibility of tool marks from a firearm.

Reference(s):

1. National Research Council, "*Ballistic Imaging"* The National Academies Press, Washington, DC, 2008.
2. Mikko D., Miller J., Flater J. Reproducibility of Toolmarks on 20,000 Bullets fired through an M240. *AFTE Journal*, 2012, Vol 44, Number 3 (Summer), Page 248 thru 253
3. Gouwe J., Hamby J., Norris S., Comparison of 10,000 Consecutively Fired Cartridge Cases from a Model 22 Glock .40 S&W Caliber Semiautomatic Pistol. *AFTE Journal*, 2008, Vol 40, Number 1 (Winter), Page 57 thru 63
4. ASME B46.1-2009. Surface Texture (Surface Roughness, Waviness, and Lay) 2009

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