Validation Study of Electrochemical Rifling

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ABSTRACT

Electrochemical machining is being used by Smith & Wesson to rifle many of its revolver barrels. This paper provides a description of this manufacturing process and a study that was conducted to evaluate whether or not these barrels will mark bullets in a repeatable and unique manner. This validation study of firearms/toolmarks identification as it applies to electrochemical rifling found that this manufacturing technique does produce unique, reproducible, and identifiable microscopic marks.

INTRODUCTION

Since 1993, Smith & Wesson has been using an electrochemical machining technique to rifle most of their revolver barrels. The only revolver barrels that are still broach rifled are .22 caliber barrels and ported barrels. The manufacture of electrochemically rifled (ECR) barrels begins with the same steps as conventional broach rifling. The barrels are drop forged from bar stock, annealed, and wheel abraded to remove scale. During the annealing process the barrels have a tendency to bend and are therefore put through a straightening operation. The barrels are next drilled and reamed using conventional machining tools and the forcing cone is made with a tapered reamer. The barrels are then ready for rifling.

The electrochemical rifling machines are made by Surftran and were specifically designed for Smith & Wesson. Each machine runs two independent workstations, each one with a single electrode manufactured by Mechanical Plastics. They are constructed of a two-inch long plastic cylinder with metal strips spiraling down its exterior. The metal strips are in the desired dimensions of the grooves, are at the appropriate rate of twist (1 turn in 18.75 inches for .357 Magnum), and are slightly inset in the plastic cylinder. The barrel is placed in the machine and is held stationary. The electrode is placed into the barrel and both are submerged in an electrolyte (sodium nitrate). The electrode travels down the barrel and rotates at the desired rate of twist. As current passes from the negatively charged electrode (cathode) to the positively charged barrel (anode), the metal is removed by electrolysis to produce the grooves by duplicating the shape of the electrode. During this operation the electrolyte flows through the barrel under pressure to remove the reaction products. This prevents the build up of reaction products on the electrode. Because the metal strips on the electrode never come in physical contact with the barrel and reaction products are not given the opportunity to build up, the electrode does not require any cleaning or maintenance. In fact, electrodes are only retired when the plastic core, which contacts the barrel to provide proper spacing and centering, wears over time. An electrode will usually remain within the tolerance of 2 thousandths of an inch concentricity for approximately 3000 inches of barrel. During our tour of the Smith & Wesson factory, they were rifling six-inch .357 Magnum caliber barrels and the ECR process took about 60 seconds per barrel.

While touring the facility, Smith & Wesson generously provided five consecutively rifled six-inch .357 Magnum caliber barrels. These barrels were rifled in the presence of one author. Each barrel was numbered in order of production, wrapped to avoid damage during transport and taken to the laboratory for further examination and testing.

PROCEDURE

The five consecutively rifled barrels were numbered in the order of manufacture. Each barrel was test fired on the same Smith & Wesson revolver, a Model 681. However, the marks present on these first sets of bullets were difficult or impossible to identify. It is believed that this is due to rapid wear of the new barrels before the microscopic characteristics stabilize. This phenomenon has been previously documented in new, unused barrels in studies conducted by Murdock[1] and Matty[2]. Their studies required a couple sets of test fires before the marks began to stabilize. However, the marks in the ECR barrels did not seem to be stabilizing as quickly. To avoid any possibility that changing marks might interfere with the study, fifty rounds of jacketed ammunition were fired from each barrel to represent the "break-in" period.

After the break-in period, test samples were fired and collected from each barrel. Microscopic comparisons showed that the barrels were reproducing their microscopic characteristics on the test fires. These samples were .357 Magnum caliber, 158 grain jacketed soft point bullets. For each barrel, six test bullets were collected. The fired bullets were randomly lettered and placed into envelopes marked with the respective barrel number.

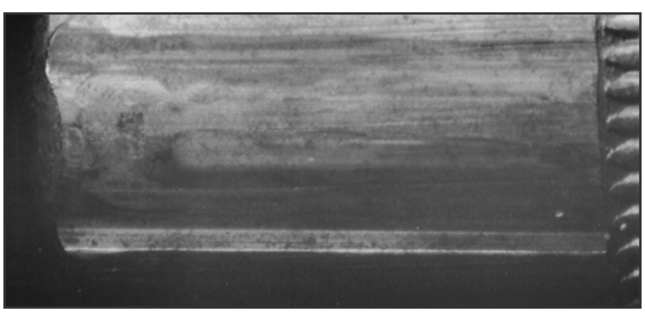
Three different tests to be conducted by a qualified examiner were created from the test fired specimens. Each test consisted of five bullets that were randomly selected from the envelopes such that one bullet from each barrel was represented. Two additional bullets were added to each test. The additional bullets provided for at least two possible identifications. However, in one test the two additional bullets had both been fired from the same barrel and therefore three identifications were possible.

Each test was given to a qualified Firearms-Toolmarks Examiner in the FBI Laboratory. These tests required twenty-one different bullet to bullet comparisons. Each examiner was asked to fill out an answer sheet and mark each comparison they made as an identification, no conclusion, or exclusion. For every identification, they were to provide information as to whether their identification was based on marks present in the land impressions alone, the groove impressions alone, or both lands and grooves independently. This distinction was made because marks produced by the lands are a result of the reaming process, while the grooves produce marks that are a result of the ECR process. Thus, different areas on the bullet represent different manufacturing processes. A total of nine examiners completed a test.

OBSERVATIONS

When the barrels were examined in the laboratory it was noted that the rifling had the general appearance of conventional rifling. However, upon closer inspection it was noticed that the shoulders between lands and grooves were not as sharp as commonly seen in broached, button, or hammer forged rifling. This was also apparent upon examination of the test fired bullets, which also had a less defined shoulder between land and groove impressions (Figures 1 through 3).

Figure 1



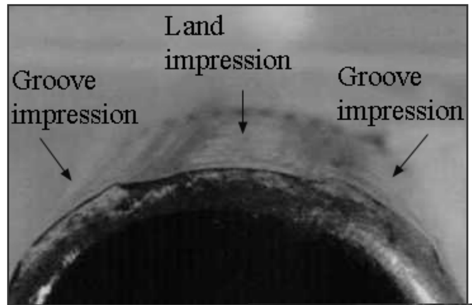
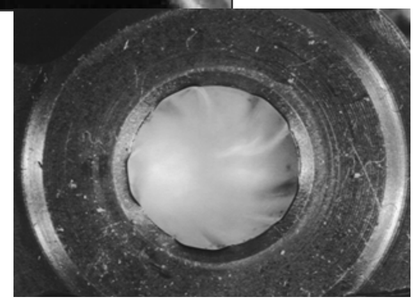


Figure 2

Figure 3



Figures 1 & 2.
Photographs of a test fired bullet showing the rounded shoulders of the land and groove impressions. Figure 2 is the base of the bullet. Figure 3 is a photograph of the muzzle end of a test barrel, showing the rifling.

The general rifling characteristics of these bullets were measured and are listed below:

Five Grooves, Right Twist
Land Impression Width: 0.097”-0.100”
Groove Impression Width: 0.116”-0.120”

RESULTS

With the exception of one of the authors, all nine of the qualified Firearms-Toolmarks Examiners in the FBI Laboratory participated in this study. Upon completion of the tests, the results were collected and analyzed. The responses from the nine examiners included no false identifications or false eliminations. All examiners reported that the identifications that they made could be made independently on the land or groove impressions. In three of the tests there was a true identification that was marked as a “no conclusion.” However, only false positive or false negative responses were considered incorrect since a “no conclusion” does not exclude the possibility that the bullets could have been fired from the same barrel.

CONCLUSIONS

Based upon one author’s personal observations during the comparison of test fired bullets from each barrel, it was clear that marks were consistently reproduced. Further, these reproduced marks were clear on both land and groove impressions, which is important since they would each be the result of two different manufacturing processes (Figures 4&5).

The results of the tests are also very positive. Without exception, all the examiners reported correct results. There were no false identifications reported which clearly indicates that the marks left on the bullets are unique to a specific barrel. This was expected in reference to marks produced by the lands, which are the result of a reaming operation. Hall[3] has previously documented the uniqueness of marks produced by reaming. The results in this study serve to further support those reported in previous studies.

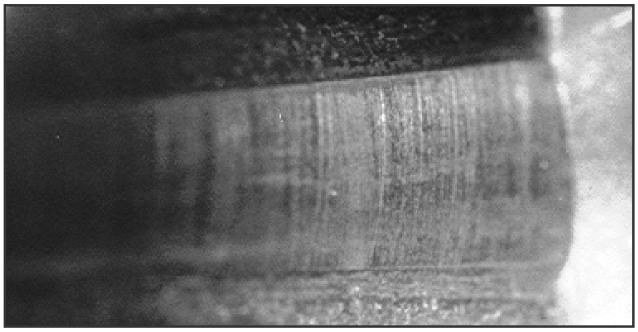


Figure 4. The marks left by the reaming process are visible on the top of the land in a test barrel.

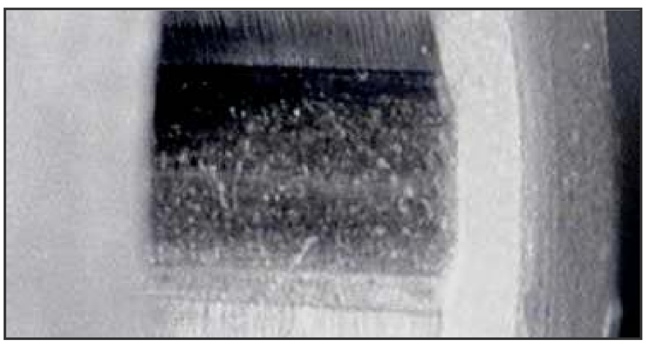


Figure 5. The marks left on the grooves are visible here. A speckled pattern is visible from the removal of metal during the ECR process.

Additionally, each examiner reported that it was possible to effect identifications based on the marks in the groove impressions alone. These marks are the result of the electrochemical rifling. This clearly indicates that the electrochemical rifling does produce unique and identifiable microscopic marks.

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