Comparison of Dust Cover Impact Marks on 200 Consecutively Fired Cartridge Cases from a Saiga 7.62x39mm Rifle

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ABSTRACT

This study examines the origin and production of dust cover impact marks on cartridge cases fired in a 7.62x39mm rifle as well as the changes that occur to the dust cover from extended or repeated use of the firearm. Two-hundred (200) brass and steel cased cartridges were fired using a new dust cover on an AK type firearm. High-speed video (HSV) was used to confirm the specific location of impact on the dust cover and identify the differing categories of impact marks that resulted based on impact location. Changes to the morphology of the dust cover were observed and documented. It was determined that these changes occur over repeated firings, affecting and likely reducing microscopic comparison qualities. The degree of change to the dust cover is dependent on the type of ammunition used.

Introduction

During the first half of 2017, a series of shootings occurred in the Seattle area which yielded over two hundred cartridge cases during the course of five months. Many of the cartridge cases found at the various crime scenes were identified to a recovered Saiga 7.62x39mm caliber, AK-47 type rifle. Historically, comparisons of the breech face area markings of this rifle type have been challenging for examiners due to manufacturing marks present on ammunition, ammunition primer hardness, and lack of markings on the firearm. Cycling marks created during firing by the ejector and dust cover areas are routinely used to supplement identification.

Several studies have been reported on the marking longevity of many types of firearms and surfaces, including chamber marks **[1]**, breech face marks on pistols **[2-7]**, and revolvers **[8]**. These studies consistently demonstrate that while some slight changes may occur over many firings, marks on cartridge cases are not altered to an extent that prevents their identification to earlier test firings. One study by Grom and Demuth even tested the reliability of IBIS correlations after firing 500 consecutive shots and found that the IBIS system (Ultra FTI, Inc.) reliably linked the fired casings **[9]**. However, none of these reported studies considered dust cover impact marks (sometimes referred to as slap marks). During this investigation, questions arose related to the persistence and reproducibility of these marks due to repeated firings.

Because microscopic marks from the breech face and firing pin of AK-47 type rifles and their associated ammunition are often limited, marks produced on cartridge cases from impact with the dust cover are often used by examiners to identify cartridge cases to the associated firearm. As can be seen from **Figures 1 and 2**, dust cover impact marks are imparted onto fired cartridge cases during the ejection process, as the cartridge case ejects and impacts the forward edge of the dust cover.

Dust cover impact marks have also been used to suggest whether a fired cartridge case was fired in an SKS type or AK type rifle based on the location of the dust cover impact mark. A study carried out by Bartocci in 2002 found that rifles of the SKS type tend to produce dust cover impact marks on the lower half of the cartridge case, toward the head, while AK type firearms tend to produce the marks on the upper half of the cartridge case, toward the mouth. Of the 141 cartridges fired collectively from forty-seven (47) SKS type rifles, 97.2% demonstrated this phenomenon. Similarly, of the 150 cartridges fired collectively from fifty (50) AK type rifles, 96.66% showed characteristics consistent with this theory. This is based on the ejection process of each type of firearm, specifically the distance from inside of the extractor to the area the cartridge case impacts on the receiver **[10] (Figure 3)**.

This study intended to identify the morphological changes that occur to the dust cover due to repeated firings, and changes to the resultant dust cover impact marks. How many cartridges can be fired (brass or steel case) before the morphological features on the surface of the dust cover are altered to the extent that identification of dust cover impact marks is no longer possible? The rate of change of the morphological features on the dust cover is likely the result of a combination of factors, which may include the hardness of the metal that comprises

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Figure 1: As the fired cartridge case is ejected from the firearm it strikes the edge of the dust cover creating the dust cover impact mark (slap mark) near the mouth of the fired cartridge case.

Figure 2: When a fired cartridge case is ejected and hits the dust cover, unique markings on the dust cover are imparted onto the fired cartridge case,sometimes referred to as 'slap marks' or dust cover impact marks. These marks viewed microscopically can be useful in making identifications between cartridge cases.

Figure 3: Characteristics of dust cover impact marks (slap marks) found on SKS-type rifles (left) and AK-type rifles (right).

the dust cover, the material of the impacting cartridge case and its hardness, as well as the location impacted by a cartridge case as it is ejected, and whether the same area is impacted repeatedly. Using high-speed video (HSV), the precise location of impact on the dust cover by ejected cartridge cases can be identified and documented throughout the life of the firearm, allowing the change in the morphological features of the dust cover to be tracked through repeated firings.

Materials and Methods*

- Saiga (EAA-Izhmash) 7.62x39mm caliber semi-automatic rifle (WSP Crime Laboratory reference collection)
- 100 7.62x39mm caliber PPU (Serbia) headstamped brass centerfire rifle cartridges
- 100 7.62x39mm caliber TulAmmo (Russia) headstamped steel centerfire rifle cartridges
- A new, unused steel dust cover for the Saiga rifle
- ForenSil (AccuTrans Forensic silicone, www.accutransusa.com)
- Chronos 1.4 HSV camera (Kron Technologies Inc., optimal resolution and frame rate, www.krontech.ca)
- Edgertronic SC1 (Edgertronic, 701 fps @ 720p, www.edgertronic.com)

*not an endorsement of any particular product

For this testing, the Saiga was fitted with a new unused steel dust cover. Prior to any testing, the forward edge of the dust cover, the edge to the rear of the ejection port, was cast using ForenSil.

Photographs of the edges of the dust cover were taken with a comparison microscope for detailed documentation prior to firing as well. Edgertronic (SC1) and the Chronos HSV cameras were utilized for this experiment to capture images of the cartridge cases as they were ejected and to map the precise location of impact on the dust cover.

In addition to the above pre-testing actions, the firing sequence for the 200 cartridges was determined as follows to test the hypotheses below:

- SET 1- 50 brass cartridges (labeled B1-B50)
- SETs 2, 3- 100 steel cartridges (labeled S1-S100)
- SET 4- 50 brass cartridges (labeled B51-B100)

An aim of this study was to determine to what degree the impact of steel cartridge cases affects the ability to make an identification between fired cartridge cases. In order to assess this, between each set of 50, (SET 1: 50 brass, SET 2: 50 steel, SET 3: 50 steel, SET 4: 50 brass) photomicrographs and casts were taken of the dust cover to document morphological changes that occurred. The dust cover impact marks on the cartridge cases were also compared on a comparison microscope and categorized based on general shape for assessment and ease of examination.

While most of the cartridges were manually loaded into the chamber, 10 samples were first loaded in a 10-capacity magazine. It was surmised that the spring tension of the magazine follower could have an effect on the dust cover impact marks produced. However, despite this potential, no extra marks of significance were observed on the cartridges fired from a magazine when compared to those cartridges which were loaded separately.

Hypotheses

- Hypothesis 1: The steel cartridge cases will produce greater and more rapid change on the dust cover, altering the surface more than the brass cartridge cases due to the greater hardness of the steel.

- Hypothesis 2: Less change will be observed within the first set of brass cartridge cases due to the softer nature of the brass.

- Hypothesis 3: Greater differences in dust cover impact mark features will be observed between brass cartridge cases fired after the steel when compared to those fired before the steel.

Results

The dust cover impact marks on the 200 fired cartridge cases **(Figure 4)** were grouped into six categories (five primary and one secondary category). These categories are based on where on the dust cover impact occurred, and the orientation of the fired cartridge case upon impact. As expected, when these two factors were the same or similar, the resulting microscopic marks were also similar. The observations of where the impact occurred and the orientations of the cartridge cases at the point of impact are important, so that an accurate account of how many cartridge case impacts it takes to cause significant change can be ascertained, as not all fired cartridge cases strike the same area on the dust cover. HSV was used to confirm the specific location on the dust cover where each cartridge case impacted and at what orientation, resulting in the different categories of dust cover impact marks.

The five primary dust cover impact mark categories included:

- Small Mark (SM) – single line with limited gross marks
- Light Frown (LF) – curves downward toward base
- Deep Smile (DS) – curves upward toward mouth
- Small Dent (SD) – nick in case with limited gross marks
- Deep Notch (DN) – deep mark with clear gross markings

*A designation of Multiple Marks (MM) was given as a secondary category and was used only for documentation. Secondary marks were not considered for the purposes of this study, although could lead to future research.

Small Mark (SM)

Fifty-two of the cartridge cases exhibited Small Marks (SM). SM were designated as a single line which lacked any deep

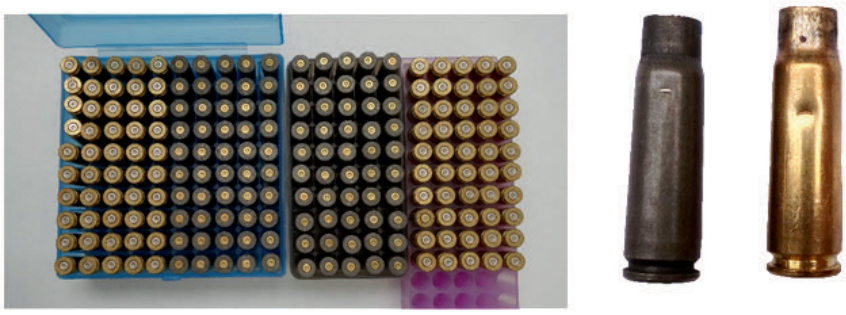

Figure 4: 200 fired cartridge cases were microscopically examined and separated into 5 groups based on morphological characteristics. 100 brass and 100 steel cartridge cases were fired in total.

definition or many long drag marks **(Figure 5)**. These marks were found evenly distributed throughout all 4 firing sets. The number of SM were split 25-27 (brass vs. steel).

Figure 5: Small Mark found on fired cartridge case B1.

Light Frown (LF)

Twenty-six of the dust cover impact marks were categorized as Light Frowns (LF). LF were defined as a mark with a slight curve downward toward the head of the cartridge case. These marks demonstrate some shearing and increased depth compared to SM **(Figure 6)**. LF were only found in brass cartridge cases: 14 cartridge cases in SET 1, and 11 cartridge cases in SET 4.

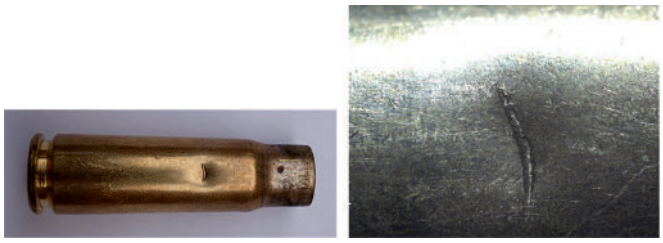

Figure 6: Light Frown found on fired cartridge case B54.

Deep Smile (DS)

Thirteen of the dust cover impact marks were characterized as Deep Smile (DS), described as a series of chatter marks that curved upward in a long line towards the neck of the cartridge case **(Figure 7)**. DS differed from other marks as it consisted of a series of chatter marks rather than a single mark. DS were identified throughout all sets, with most of them found in SET 4.

Small Dents (SD)

Small Dents (SD) were accounted for in 54 of the cartridge cases. SD are characterized as a small nick in the cartridge case, with limited gross marks **(Figure 8)**. The striae identified within the marks were curved, inconsistent and difficult to compare. SD were found in all sets; however, 48 out of the 54 cartridge cases marked with SD were produced on the

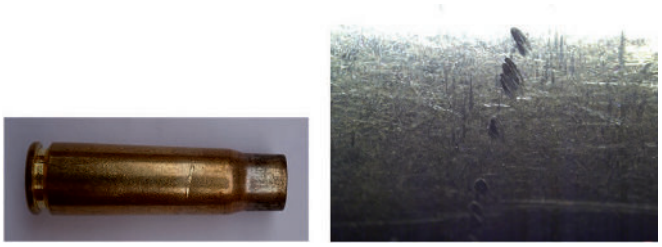

Figure 7: Deep Smile found on fired cartridge case B58.

steel cartridge cases as opposed to the brass cartridge cases. When found on brass cartridge cases, multiple marks were consistently observed.

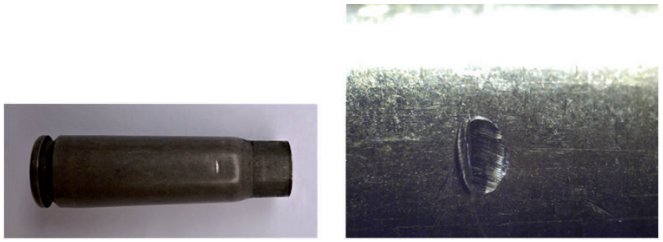

Figure 8: Small Dent found on fired cartridge case S30.

Deep Notches (DN)

These marks are defined as a single deep mark found on the cartridge case, exhibiting more definition than that of the SD. Deep Notches (DN) were found in 54 sampled cartridge cases **(Figure 9)**. SET 1 (brass) had 15, SET 2 and SET 3 (steel) had 20 combined, while SET 4 (brass) had 19 total DN marks. While this mark was similar to the SD mark, it possessed greater depth and width. It consisted of a more even combination of gross and fine striae with distinct characteristics reproduced across the cartridge cases in the category.

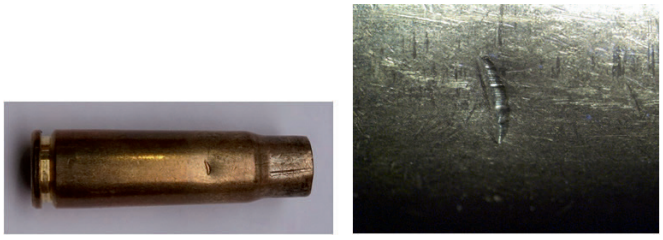

Figure 9: Deep Notch found on fired cartridge case B14.

Multiple Marks (MM)

Twenty-two of the cartridge cases contained Multiple Marks (MM), spanning across all categories. These marks were not closely examined, but were seen on the HSV corresponding

to cartridge cases impacting at least two different areas on the dust cover as they were ejected.

No Marks

Three of the cartridge cases did not exhibit any discernable dust cover impact marks. HSV recording the ejection of these cartridge cases showed that the cartridge cases completely cleared the area of the dust cover upon exiting the firearm.

The frequency of each mark appearing in each set is detailed in **Figure 10**.

Using HSV, the precise location of impact on the dust cover was identified as indicated in **Figure 11**. Photomicrographs taken between each set depict the morphological changes occurring on the dust cover surface, particularly highlighting the loss in detail and definition after repeated firings. The angle and orientation of impact was further documented by use of HSV corresponding to each of the dust cover impact mark categories **(Figure 12)**.

Photomicrographs of the dust cover surface throughout the study are documented in **Figure 13**. It is evident that over the course of repeated firings that the surface of the dust cover becomes worn down, losing nearly all of its original microscopic landscape.

In +0 cartridge cases, there is a well-defined edge and, on the right, two small 'nubs' which hang off the edge. After +50 brass cartridge cases there is only one nub after the first was removed. Slight polishing begins to materialize and the edge loses definition. After the impacts of +50 brass and +100 steel cartridge cases, the remaining nub is polished away becoming nearly indistinguishable from the rest of the topography of the dust cover.

Casts of the surface of the dust cover, taken between each

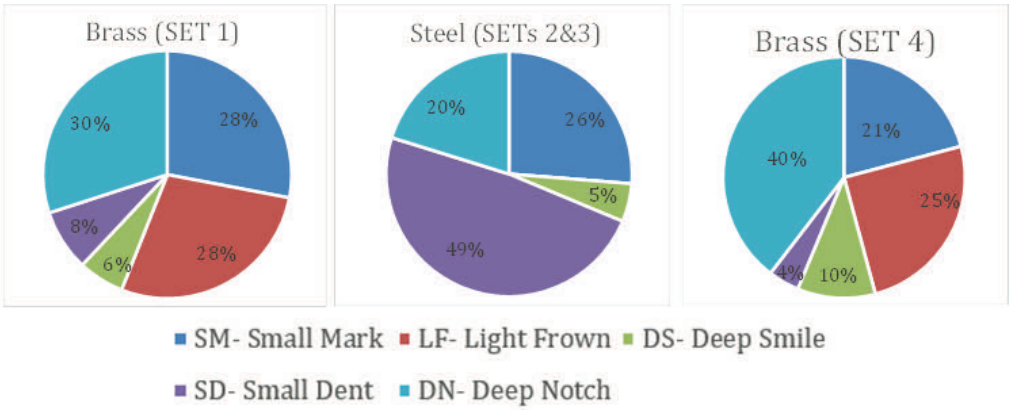

Figure 10: Frequency of each type of dust cover impact mark (slap mark) within SET 1, Brass, SETs 2&3, Steel and SET 4, Brass.

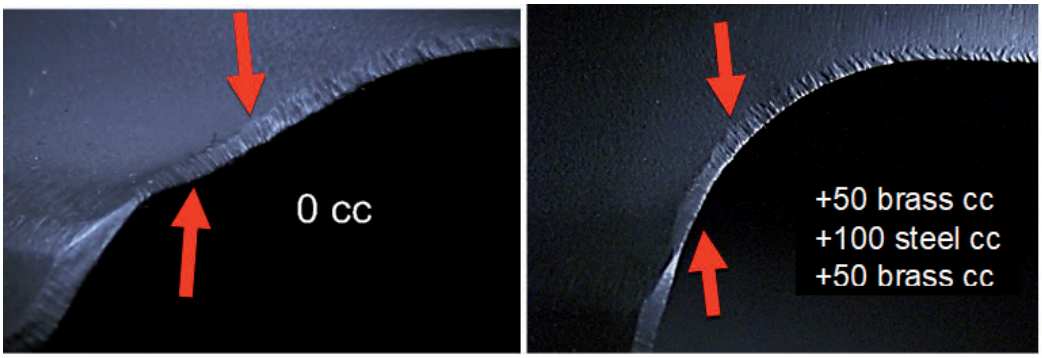

Figure 11: Identified location of impact on the dust cover by fired cartridge cases, obtained through review of HSV showing +0 cartridge cases and +50 brass, +100 steel, +50 brass cartridge case impacts.

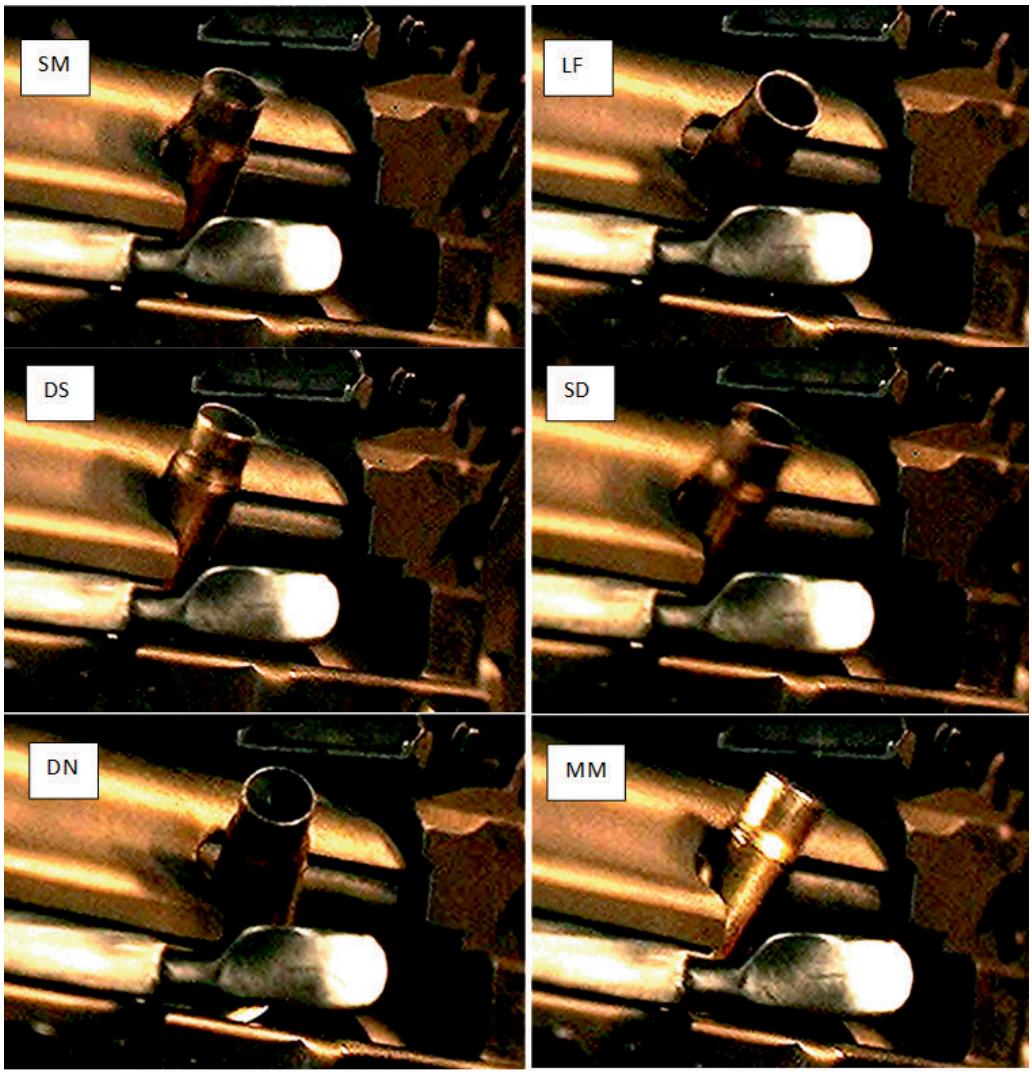

Figure 12: HSV showing the location and angle/orientation of impact on the dust cover made by fired cartridge cases upon exiting the firearm, resulting in the five categories of dust cover impact marks (slap marks) identified in this study.

set of firings, are documented in **Figure 14**. Overall, they reveal a loss in detail of the distinctive striations present on the surface of the dust cover, specifically where the cartridge cases impacted it (as witnessed on HSV). This difference is observed most significantly in the comparison between the cast taken after 50 brass cartridges were fired vs. after 100 brass and 100 steel cartridges were fired. As **Figures 13 and 14** demonstrate, the location on the edge of the dust cover where cartridge cases most frequently impacted the surface displays a softening and loss of the gross striations it possessed before the steel cartridge cases impacted it.

Discussion

For the purpose of this study, one category of marks was chosen for microscopic comparison across all 4 sets. This was done in order to examine the changes that occurred to the morphology of the dust cover and the resulting microscopic marks due to repeated firing of brass- and steel-cased ammunition. Since both DN and SM categories were found throughout all 4 sets of cartridge cases, comparisons could be made between each set. The DN category was chosen as the primary focus of this study because the striations within the mark tended to be more consistently well-defined than those in the SM category. Additionally, DN marks were more numerous, particularly in SET 4. Therefore, the effects of steel cartridge case impacts on the dust cover could be more comprehensively analyzed. Several comparisons were made between cartridge cases in SET 1, between cartridge cases in SET 1 and cartridge cases in SETs 2 and 3 (SET 3 not discussed below as results were

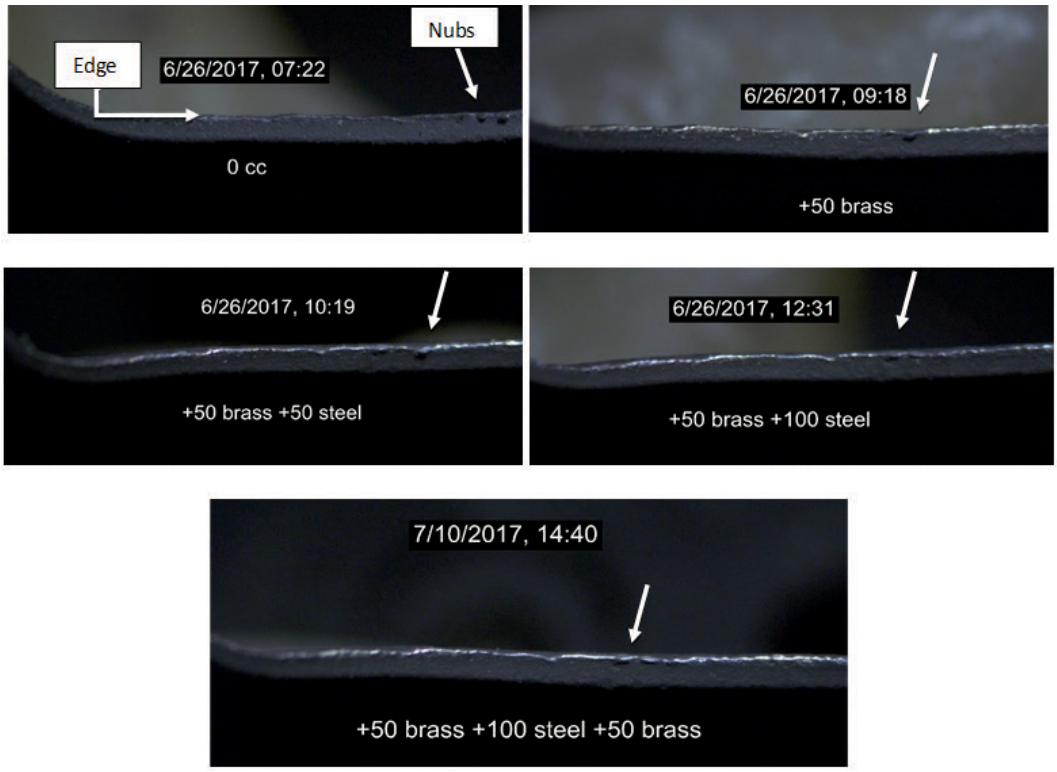

Figure 13: Progression of the dust cover edge where fired cartridge cases struck, viewed microscopically and photographed between each set of 50 fired cartridge cases.

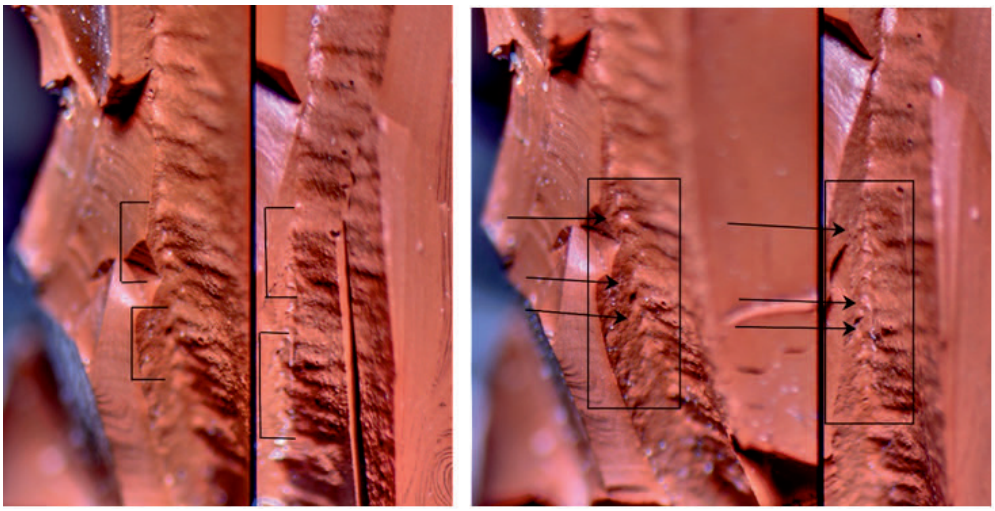

Figure 14: Two comparisons between casts of the dust cover surface after +50 brass cases (left/left) vs. +100 brass and 100 steel cases (right/right). Bracketed/boxed areas indicate the area on the dust cover where cartridge cases impacted most frequently. Arrows further specify the areas where changes in the surface of the dust cover are most evident. The casts on the left possess thick gross marks, while the casts on the right show these toolmarks have diminished.

similar to SET 2), cartridge cases in SET 1 (before steel impact) and cartridge cases in SET 4 (after steel impact), and between cartridge cases within SET 4. Based on these comparisons, it was concluded that impacts from the steel cartridge cases in SET 2 and SET 3 significantly altered the surface of the dust cover, resulting in less distinct microscopic marks.

A firearm is a system of tools that generate a collection of identifiable marks on a cartridge case. One or more of these marks are utilized for microscopic comparison and identification. Throughout this study, only one tool mark is analyzed. It is worth acknowledging that identifications are not typically made based on one tool mark alone. Examiners will often use, at minimum, 2 different tool marks to make an identification. In the case of dust cover impact marks, the fact that the dust cover on a firearm can be easily replaced or exchanged with another should be taken into consideration when making an identification.

SET 1-brass

Comparisons made between the brass cartridge cases in SET 1, which were fired before the steel cartridges, consistently exhibited well-defined striations and several areas of correspondence. B3 (SET 1) was used as a reference for comparison throughout all stages of firing. The comparison of B3 vs. B14 demonstrated well-defined and detailed microscopic marks. Several areas of correspondence existed and there was no significant change in marks **(Figure 15)**.

Figure 15: B3 vs. B14 from SET 1

Within SET 1, the greatest potential for change to be observed would be from the comparison of two cartridge cases separated from one another in the firing sequence. However, comparisons between B3 and B47 still exhibited no significant changes. Several areas of correspondence were observed, and agreement was consistent with prior comparisons between cartridge cases fired consecutively **(Figure 16)**. Comparisons within SET 1 demonstrated the minor impact brass cartridge cases have on the surface of the dust cover and their limited potential to alter microscopic markings over repeated firings. Overall correspondence was clear and significant individual markings were observed that were sufficient for identifications between cartridge cases throughout all stages of SET 1. The significant correspondence in individual characteristics between impact marks in SET 1 is of valuable quality for an identification.

Figure 16: Comparison between B3 vs. B47 at 32x magnification (left) and 57.6x magnification (right).

SET 1-brass vs. SET 2-steel

Comparisons between brass cartridge cases in SET 1 and steel cartridge cases in SET 2 again showed agreement in individual characteristics that was sufficient for an identification, as demonstrated in the comparison between B3 and S4 **(Figure 17)**. Similarly, comparison between B3 and S15 showed correspondence sufficient for an identification **(Figure 18)**. As more steel cartridge cases impacted the dust cover, a loss in detail and finer, individual striations within the DN dust cover impact mark was observed. This is seen in the comparison between B3 vs. S27 in which gross marks are evident on S27, but the mark lacks the level of detail as seen on B3 **(Figure 19)**. This comparison lacks the quantity and quality of agreement necessary for an identification based on the impact mark alone but could be used to lend weight to an identification.

SET 1-brass vs. SET 4-brass

Comparison between brass cartridge cases from SET 1 and SET 4 showed a significant amount of change in the marks observed. The striae within the marks on cartridge cases from SET 1 are deep, well-defined and easily distinguishable, as demonstrated by the comparison between B3 vs. B14 (**Figure 15**). In contrast, the striae in the DN marks on cartridge cases in SET 4 are worn down, muted and less distinguishable. This difference is apparent in comparisons made between B3 and B70 as well as B47 vs. B70 **(Figures 20 and 21)**, among others. Although some of the microscopic detail was diminished on some of the mark types, identifications could be made between SET 1 and SET 4 from dust cover impact marks.

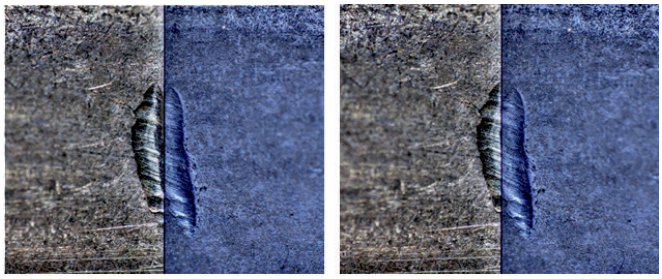

Figure 17: B3 from SET 1 vs. S4 from SET 2.

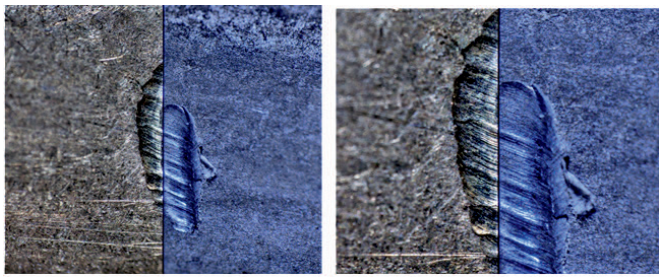

Figure 18: B3 from SET 1 vs. S15 from SET 2

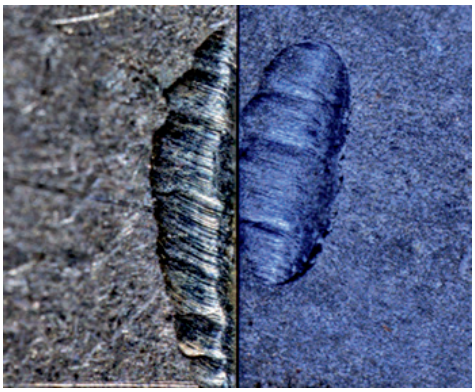

Figure 19: B3 from SET 1 vs. S27 from SET 2.

While the impressions exhibit correspondence between some of the gross marks and similarities in the overall outline, they lack the amount of finer detailed, individual correspondence. Agreement between gross striations is seen in the comparison between B47 and B70 (**Figure 21**), for example, but the level of detail and agreement between finer striations is reduced. Identification is more difficult based on the impact mark alone.

SET 4-brass

Dust cover impact marks on cartridge cases in SET 4 (after steel impact) showed muted, less distinct microscopic striations when compared to marks on the SET 1 cartridge cases. The DN marks in this set lacked the number of fine striations seen in SET 1 and thus individual correspondence; however, gross marks were still visible, even if less pronounced. This is

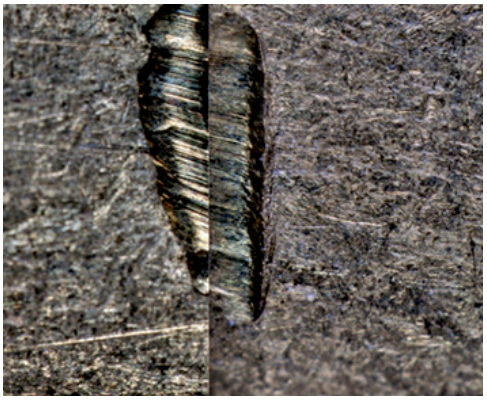

Figure 20: B3 from SET 1 before steel impact vs. B70 from SET 4, after 100 steel cartridge case firings.

Figure 21: B47, at the end of SET 1 vs. B70, fired towards the beginning of SET 4, after 100 steel cartridge case firings.

demonstrated in comparisons between B72 vs. B70 and B94 vs. B70 **(Figures 22 and 23)**. These DN marks do not exhibit the high levels of distinctive detail present in SET 1 prior to steel impact, therefore, an identification cannot be made based solely on the impact mark. However, while impact marks in this set lacked individual correspondence, there may be enough gross correspondence to assist in an identification. Due to the similar appearance of markings on cartridge cases fired more closely together, these comparisons show greater correspondence than comparisons between cartridge cases in SET 1 and SET 4, where an extensive amount of change on the surface of the dust cover occurs in between the firing of these sets. It was noted that further change in morphological features of the marks did not occur in SET 4 at the same rate as that sustained in SET 2 and SET 3. The significant changes that occurred during SET 2 and SET 3 made identifications less likely within SET 4.

Figure 22: B72 vs. B70 both from SET 4, after steel cartridge case firings, showing similar worn down markings.

Figure 23: B94 vs. B70, both from SET 4.

SET 2-steel

In comparing steel vs. steel DN marks, striations were less distinct in contrast to brass cartridge case markings; however, identifications were still made. Comparison between S4 vs. S15 shows clear correspondence between markings **(Figure 24)**. Because steel is a harder material, impact on the dust cover imparts lower quality DN detail versus a softer material such as brass.

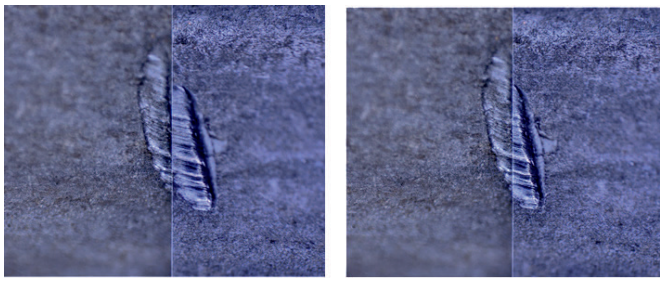

Figure 24: Steel cartridge cases from SET 2: S4 vs. S15

Conclusion

Although the dust cover on our Saiga rifle had undergone a significant amount of microscopic change within just 200 rounds of fire, it is evident that the vast majority of those changes occurred within only 100 shots of steel cased ammunition. Additional use will likely continue to wear away the edge of the dust cover, further altering the forward edge of the dust cover and the resultant impact marks on the fired cartridge cases.

In this experiment, the steel cartridge cases caused most of the change sustained by the steel dust cover. These changes in morphological features and in the microscopic marks imparted on the cartridge cases are to be expected, as steel is a much harder material than brass. The repeated impacts of the brass cartridge cases did not cause the imparted markings to change so significantly that identification to earlier firings was not possible. The steel cartridge cases tended to have less defined and distinctive microscopic marks, while the markings on the brass cartridge cases were abundant and well defined. The use of HSV was vitally important to be able to evaluate the dust cover impact marks that would be most appropriate for microscopic comparison.

Most importantly, our study determined that the marks generated from impact on the dust cover become less distinctive and identifiable over repeated firings. The topography of the edge of the dust cover that is typically impacted becomes peened and somewhat polished from multiple cartridge case impacts during the ejection process. This is in opposition to other markings imparted by a firearm which can become more unique and distinctive through use. It is certainly possible that over more firings and amount of use, new individual markings may be created; however, within the first two hundred rounds using our rifle, more specifically 100 steel cased cartridges, the marks became less distinct and significant for comparison.

Serial Shooting Significance

This data can be useful in analyzing markings on cartridge cases when it is suspected that a single firearm has been used repetitively in a series of crimes, and in understanding how marks on cartridge cases may have the potential to change. In the case of this serial shooting, the firearm was thought to have been purchased new and used in multiple locations over a series of months. While dust cover impact marks are often instrumental in determining firearm type as well as linking cartridge cases from different crime scenes, this study demonstrated that changes can occur that may diminish the microscopic utility of the marks. Most concerning for this study were the microscopic changes that occurred due to the material of the cartridge case. Different ammunition could cause a different rate of wear, which is another variable to be weighed and considered when drawing scientific conclusions.

Further Research

This study only evaluated one subset of AK-47 dust cover impact marks, in one particular rifle. Not only can each of the

five categories of marks be further studied with multiple dust covers, the effects of different types of ammunition can also be explored.

It may also be beneficial to obtain several new dust covers, possibly consecutively produced, and further compare the effects of brass cartridges versus steel cartridges separately. This would expand knowledge in the field in regards to the amount of change caused by multiple firings of one type of ammunition, compared to another.

3D HD imaging of the surface of the dust cover is currently being explored utilizing the Evofinder 3D technology. This will allow for a more comprehensive look at the morphological changes that occur on the dust cover after repeated firings.

Finally, it would also be beneficial to conduct tests with a higher number of firings. Due to the inexact ejection of the cartridge case, the dust cover is being impacted in different areas by each cartridge case. In this study, the deep notch mark was found 54 times, which suggests that spot on the dust cover was only hit 54 times. It would be constructive to have a greater number of shots, so that those changes could be tracked.

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