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An investigation into the factors that influence toolmark identifications on ammunition discharged from semi-automatic pistols recovered from car fires

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A B S T R A C T

Following a shooting incident where a vehicle is used to convey the culprits to and from the scene, both the getaway car and the firearm are often deliberately burned in an attempt to destroy any forensic evidence which may be subsequently recovered. Here we investigate the factors that influence the ability to make toolmark identifications on ammunition discharged from pistols recovered from such car fires. This work was carried out by conducting a number of controlled furnace tests in conjunction with real car fire tests in which three 9 mm semi-automatic pistols were burned. Comparisons between pre-burn and post burn test fired ammunition discharged from these pistols were then performed to establish if identifications were still possible. The surfaces of the furnace heated samples and car fire samples were examined following heating/burning to establish what factors had influenced their surface morphology. The primary influence on the surfaces of the furnace heated and car fire samples was the formation of oxide layers. The car fire samples were altered to a greater extent than the furnace heated samples. Identifications were still possible between pre- and post-burn discharged cartridge cases, but this was not the case for the discharged bullets. It is suggested that the reason for this is a difference between the types of firearms discharge-generated toolmarks impressed onto the base of cartridge cases compared to those striated along the surfaces of bullets. It was also found that the temperatures recorded in the front foot wells were considerably less than those recorded on top of the rear seats during the car fires. These factors should be assessed by forensic firearms examiners when performing casework involving pistols recovered from car fires.

1. Introduction

Over 80% of gang related shooting homicides in the Republic of Ireland from 2010 to 2013 involved the use of a handgun [1]. The brands of firearms used in crime mirror their commercial and military popularity, which in turn reflects their availability to criminals. Prevalent combat handguns are trafficked into criminal hands having followed the same routes as other illegal commodities such as narcotics [2]. Serial numbers are often deliberately removed from these firearms so as to disguise their true identity and source from law enforcement agencies. In the battle against such criminal entities, law enforcement organisations around the world have sought forensic scientific knowledge to effectively trace the crimes in which these weapons have been used.

The theory of forensic firearms identification is based on the premise that a gun leaves a unique signature on the ammunition that has passed through it [3]. These unique characteristics are random imperfections or irregularities produced as an artifact of manufacture and/or caused by use, corrosion, or damage [4]. Firearms and discharged ammunition from shooting incidents are submitted to forensic firearms examiners to determine whether the latter was discharged from the former. This is achieved by comparing exemplar samples of ammunition known to have been discharged from the firearm, commonly called test fires, to the discharged evidential ammunition recovered from the crime scene. If the firearms examiner is satisfied that there is sufficient agreement between these individual characteristics on both sets of discharged ammunition, an opinion offering a positive identification between both can be given. This opinion is based on the firearms examiner's experience and knowledge gathered over years of casework as well as specific training and well-developed methodologies [5].

Following a shooting incident where a vehicle is used to convey the culprits to and from the scene, the getaway car and the firearm are often burned in an attempt to destroy forensic evidence. The majority of handguns examined by the Garda Ballistics Section in the Republic of Ireland between 2010 and 2013 that have been excavated from burned out cars, which are listed in Table 1, are either discovered on top of the

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Table 1
Firearms recovered in burned cars from 2010 to 2013 (* Polygonal rifling).

Date	Caliber	Model	Location	Positive identification	
				Cartridge case	Discharged bullet
28/06/10	9 mm Luger (×2)	Glock 17 & CZ75	Driver foot well	Y Y	N* Y
28/09/12	0.357 Magnum	Ruger GP100 Revolver	Front passenger foot well	Y	Y
24/09/12	9 mm Luger	CZ75	On rear seat	N	N
15/07/13	0.25 ACP	Baikal MP441	On rear seat	N	N
24/08/13	9 mm Luger	CZ75	On rear seat	Y	N
29/08/13	0.38 SPL	Colt Cobra	On rear seat	N	N

rear seats or in the front foot wells with greater success being achieved in making identifications involving those recovered from the foot wells [1]. Additionally, it has been found that firearms recovered from fire debris do not always impart the same firearms-generated toolmarks on the discharged ammunition as they did beforehand. Discharged ammunition collected at crime scenes can be readily identified to one another, but difficulties can arise when comparisons are performed between test-fired ammunition from the suspected firearm post-burnout [6–10]. Firearms-generated toolmarks used to make identifications between the ammunition found at crime scenes are no longer present or have changed on the test-fired ammunition discharged from the firearm following burning in the vehicle. A specific problem encountered by law enforcement agencies is that samples of unaltered exemplar test fired ammunition known to have been discharged from the firearm before it was burned is typically not available to investigators to aid them in comparison examinations with the discharged evidential ammunition from the crime scene. The reason for this lack of historical data on a firearm is the clandestine nature of how that firearm is trafficked into criminal hands often with all identifying serial numbers obliterated making it difficult to trace its origins and acquire pre-burn test fires if available.

The aim of the present study is to investigate what factors influence the ability to make toolmark identifications on ammunition discharged from handguns following car fires. The effect that car fires have on the surface structure of handguns and how it could alter the firearms generated toolmarks imparted onto discharged ammunition will be explored. The possibility that the location within the interior of the vehicle that the pistol is placed in relation to the source of the fire has an impact on the level of heat the firearm is exposed to will also be examined. Previous studies have investigated whether or not it is possible to make identifications between sets of test fires discharged from firearms after they have been burned in fires [7–9]. It is proposed through this work to determine how the fire alters the surfaces of the component parts of the firearm, namely the barrel, slide and firing pin which bear onto the surface of ammunition imparting discharge-generated toolmarks. The likelihood that the high temperatures generated in the car fires alone can alter the surface morphology of these components will also be determined. The possibility that some other factors such as the combustibles generated in the car fires or the methods used to extinguish the car fires have an influence on these surfaces will also be investigated. It is hoped that the findings of this study will increase firearms examiners' current knowledge on how firearms-generated toolmarks on ammunition discharged from pistols subjected to car fires alter after having been burned.

2. Experimental

2.1. Experimental overview

A consignment of 9 mm Luger caliber CZ-85B semi-automatic pistols was seized at Dublin Port on the 25th of July 1997. All of the pistols were of a similar construction and did not appear to be modified in any way, with the addition of aftermarket barrels, for example. No suspects were apprehended with the weapons. The pistols, none of which bore serial numbers, were test fired at the time and compared against the outstanding crime index held at the Garda Ballistics Section, with negative results. Forensic examination revealed no history of previous usage and their condition indicated that they were relatively new. Permission was sought and granted to destroy the firearms through the present study. A CZ-85B model semi-automatic pistol was examined to determine what materials the barrel, slide and firing pin were made from and establish their microstructures. Controlled furnace tests were performed in conjunction with two car fires to establish how samples of these component parts behaved in the controlled and real car-fire environments. The surfaces of these parts were imaged before and after these burning processes. Following this, comparisons were made between both sets of surfaces to monitor what changes had occurred. Three more CZ-85B semi-automatic pistols attached to thermocouples were also burned in the first of the two car fires. Comparisons were then performed between pre-burn and post-burn sets of test-fired ammunition from the pistols to establish whether identifications were possible or not. A second car was burned and the temperatures in two locations, namely the front foot well and on top of the rear seat, were recorded.

2.2. Pre-burn tests

Three CZ-85B pistols were selected and test fired with two different brands of ammunition frequently encountered during case work. The first was Sellier and Bellot brand ammunition with a 115 grain Full Metal Jacket brass jacketed bullet, brass case and brass primer. The second was CCI brand ammunition with a 115 grain Full Metal Jacket copper jacketed bullet, brass case and nickel primer. A mix of brands with brass, copper and nickel plated ammunition components which had different physical properties were chosen to ensure that all possible discharge generated toolmarks could be replicated to increase the potential for possible identifications [11]. Three rounds of both types of comparison ammunition were recovered from each pistol. The discharged generated toolmarks on the discharged bullets and cartridge cases were then evaluated to establish if they were suitable for comparison purposes. A fourth CZ-85B pistol was disassembled and its slide, barrel and firing pin were sectioned for metallurgical characterization.

2.3. Spark optical emission spectrometry

An OBLF GS 1000-II (Witten, Germany) Spark Optical Emission Spectrometer (Spark OEM) was used to determine the alloy composition of the pistols slide, barrel, and firing pin. During Spark OEM testing, sample material is vaporized with the testing probe by an arc spark discharge. The resulting atomic/ionic excitation and subsequent decay will result in the emission of electromagnetic radiation (light). The radiation emitted is passed to optical detectors where it is dispersed into its spectral components. From the range of wavelengths emitted by each element,