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Restoration of engraved marks on steel surfaces by etching technique

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Abstract

It is known that restoration of erased engraved identification marks on the engine and the chassis of a car or on a firearm has low success rate. Unlike stamping, engraving on a metal surface leaves no pronounced, permanent subsurface deformation in the crystalline structure, also called dislocation that can be revealed by suitable methods. Hence, the current research work investigated whether metallographic reagents used in the restoration of stamp (compression) marks could be applied to recover engraved marks on steel surfaces and also to establish the sensitivity and effectiveness of some of these reagents for the restoration of the marks.

Experiments were conducted by mechanically engraving alphanumeric characters on several steel plates using a computer controlled engraving machine called Gravograph. The markings were later erased from the above steel plates by removing the metal in stages of 0.01 mm through 0.04 mm below the bottom of the engraving. Several plates were thus prepared wherein each one had been abraded to a specific depth. Then eight metallographic reagents were tested on each one of the above erased plates using a swabbing technique. The results had shown that while most of the reagents were able to restore marks up to certain levels of erasure, the reagent 5 g copper sulphate, 60 ml water, 30 ml concentrated ammonium hydroxide and 60 ml concentrated hydrochloric acid restored marks erased to a depth of 0.04 mm below the engraving depth, thus presenting itself the most sensitive reagent. Quite significantly, the above reagent was also able to decipher successfully the original engraved marks that had been erased and engraved with a new number, or obliterated by centre punching.

The results of this research work should benefit the forensic practitioners engaged in the serial number recovery on vehicles, firearms and other objects.

Keywords: Criminalistics; Identification methods; Engraved marks; Stamp impressions; Restoration; Etching; Serial number recovery

1. Introduction

A problem of common occurrence in criminalistics is the restoration of erased or obliterated marks such as serial numbers on the chassis and the engine of a vehicle, or on a firearm and personal identification marks or monogram on jewelry and items of antique value. In some instances recovery of such original marks provides an important investigative aid. The most common techniques are stamping and engraving, though other techniques may also be encountered. When a number is stamped (indented) with a punch, the grains around and beneath the indentation are deformed, and the depth to which such deformation extends depends on the material in question, the size of the punches and the force, which is used in making the impression [1–4]. It is known [2,3] that stamping operation causes extensive plastic deformation that results in an ''imprint'' of the stamp marks below the surface. Restoration of the plastic deformation by etching technique, once the number is erased depends on the fact that certain reagents show difference in etching behaviour between deformed and undeformed metal. These reagents form etch pits and dissolve away the plastically deformed metals more rapidly. Thus, the number becomes visible because of difference in light reflectivity [2]. These plastically deformed regions generally become more diffuse with increasing depth below the stamp mark, until a depth is reached beyond which the stamp marks can no longer be restored. Turley [3] studied the relation between the depth of the stamp mark and the depth to which the stamp mark can be restored using both etching and magnetic techniques and found that the depth of restoration increased with increasing depth of stamp mark. However, he found this increase to be nonlinear. For stamp marks of small depth, the depth of restoration was proportionately

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greater. When he studied the ratio of the depth of restoration to the depth of the stamp marks, he noticed that for stamp marks of small depth (0.1 mm) the ratio was 4 to 5, whereas for large depth of stamp mark (0.4 mm) the ratio was about 2. He also found that increased stamp size also resulted in an increase in the depth of restoration. It is also known that a blunter die produces plastic flow to a greater depth than the sharper V-shaped die [2]. There is much published work in the restoration of erased stamp marks and many successful recoveries are reported in literature [1,4–6]. Recently Nalini and Hemalatha [6] have suggested dusting the restored number with a fluorescent powder and lifting it using clear adhesive tape. They found excellent contrast in the marks when the lift was viewed through 550 nm barrier filter using an alternate light source at 450 nm.

In contrast with stamped marks, engraving marks are shallow grooves. They are produced by removal of the metal by using mechanical, electrical or laser etched techniques. Unlike the stamping operation the underlying metal during engraving will have no or little plastic deformation. Hence erasure of the marks is quite effective and restoration is more difficult. It is reported that in the case of laser etched engraving the thermally altered area around the impression called heat affected zone (HAZ) is only a few microns (0.00008–0.0001 in. or 0.002–0.025 mm) deep and the alteration caused to the subsurface crystalline structure is extremely minimal [7]. Nickolls [4] suggests that the engravings on plated articles can be restored by etching methods making use of the fact that when such numbers are erased traces of the plating metal are still present on the filed area. In a case where an article is engraved and plated one can choose an etching solution that will preferentially etch them. He also cautions that engravings on homogenous metals cannot be developed in this way. He suggested specular reflection for identification of electric engravings. Nickolls [4], who lists a number of etching reagents for different metal surfaces, has commented that there is no routine or guaranteed method of restoration of engraved marks.

In recent years engraving marks are more popular and are often used in the steel components of a vehicle or a semiautomatic pistol [7]. They are also routinely used on gift articles and jewelry. Although there are a few successful cases reported in the literature [1,4,7], no systematic study that could be applied to reveal engraved marks was found in the literature. Further no quantitative information is available concerning the depth to which engraved marks could be restored. Also while restoring engraved marks, knowledge of the feasibility of restoring them should be of great value.

Hence the present work investigates the relative sensitivity and effectiveness of some standard metallographic reagents in restoring erased engraved marks. This is done by determining the maximum erasure depth through which the original engraved marks are revealed by each one of the metallographic reagents.

2. Experimental procedure

2.1. Engraved plates

A number of steel plates (10 cm × 3.5 cm × 1.5 mm each) were selected and engraved with a combination of alphanumeric characters ‘‘W84’’ using the computerized mechanical engraving machine known as Gravograph (Gravograph-UNICA TX, USA). The machine made reproducible engraving marks on each plate. (Refer Section 2.2). The plates were labelled appropriately, since each one will be erased to a different depth and will then be treated with a specific etching reagent.

2.2. Erasure of the engraving

Prior to the erasure process the initial thickness of each steel plate was measured using a micrometer gauge. The engraved marks were then abraded on silicon carbide abrasive papers down to the required depths below the bottom of the engraving. The depth of the original engraving was determined by measuring the thickness of the plate before and after the engraved marks was removed till its depth. The depth of this engraving was found to be 0.03 mm in all the plates.

A series of five plates of five different erasure depths as described below was prepared for etching. The first engraved plate was erased just until the visible engraving depth had been totally removed. (This plate is referred as 0.00 mm plate in Table 2.) The remaining four plates were abraded, respectively, to 0.01, 0.02, 0.03 and 0.04 mm below the bottom of the engraving depth. The plates were erased with P80, P150 and finished with fine grade P320. Since eight reagents were to be tested for their sensitivity, eight series of the above plates totaling 40 metallic specimens were prepared for the experiments.

The engraving marks were erased evenly so that the erasure depths were comparable among all the plates in the eight series. Besides, the difference in the depth of the erased marks between two successive plates was just 0.01 mm, so care was taken during erasure. Repeated thickness measurements were taken while erasing the plate to ensure correct erasure depth.

2.3. Selection of etching solutions

The eight metallographic reagents recommended by several workers [2,4,8–11] for the restoration of stamp marks on steel surfaces were applied to treat every one of the above plates erased to a different depth. The reagents, their preparation schemes, and the references are shown in Table 1.

2.4. Etching technique

The procedure used for etching the steel plates consisted of cleaning the surface with acetone and applying the reagent to the area with a cotton wool swab with a gentle rubbing action [4,9]. After about one minute the reagent was rinsed off with acetone and any number revealed was observed. The process was repeated for about 5 min and the plate was inspected for the appearance of any marks. If no marks had appeared by then, etching was continued for more time ranging from 10 min to a total of 1 h, until it is obvious that nothing more was coming. Since each one of the eight reagents was to be tested on five different plates erased to varying degrees of erasure, the following procedure was adopted. First the plate that was erased