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Restoration of Stamp Marks on Steel Components by Etching and Magnetic Techniques

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ABSTRACT: The relation between the depth of the stamp mark and the depth to which the stamp mark can be restored has been determined using both etching (Fry's reagent) and magnetic techniques. The depths of restoration increased with increasing depth of stamp mark. Increasing the stamp size also resulted in an increase in the depth of restoration. For new stamp marks, the magnetic technique was more sensitive, giving, in some cases, depths of restoration about 10% greater than the maximum depths determined by etching. For old stamp marks, the sensitivity of the magnetic technique was considerably reduced, whereas the etching technique was unaffected and therefore was the more sensitive. The etching technique could also often restore stamp marks which had been obliterated by overpunching, whereas the magnetic technique could not. A recommended procedure for the restoration of stamp marks is given.

KEYWORDS: engineering, identification systems, steels, stamp marks, restoration, magnetic particle tests, etching

Identification stamp marks are often removed from steel components by processes such as filing and grinding to prevent their identification. Subsequent restoration of these stamp marks is often necessary for identification purposes. The stamping operation causes extensive plastic deformation to occur in the metal beneath the stamp mark, and an imprint of the stamp mark is left below the surface in the form of plastically deformed regions. The basis of the techniques used to restore removed stamp marks is that they are capable of revealing these plastically deformed regions. These plastically deformed regions generally become more diffuse with increasing depth below the stamp mark, until a depth is reached beyond which the stamp mark can no longer be restored.

When attempting to restore stamp marks, a knowledge of the feasibility of restoring them would be of considerable benefit. In this regard, very little quantitative information is available concerning the depth to which stamp marks can be restored, though it would be expected to increase with increasing depth of stamp mark. Hence, the purpose of this present investigation was to establish the relation between the depth of the stamp mark and the depth of restoration, this latter parameter being the depth below the stamp mark to which the stamp mark can be restored. The two parameters are shown schematically in Fig. 1, and the relation between them was determined by using both etching and magnetic techniques. The etching technique relies on the difference in etching behavior between deformed and

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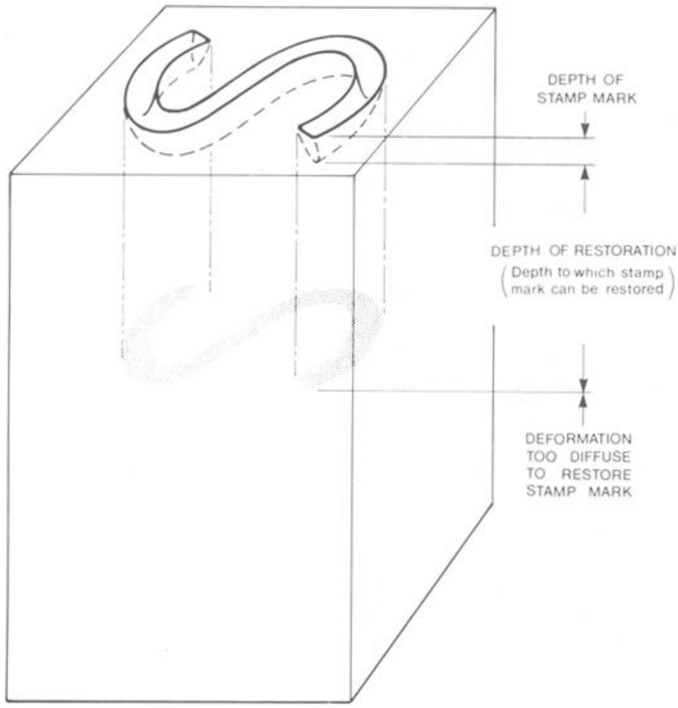

FIG. 1—*Schematic illustration showing depth of stamp mark and depth of restoration.*

undeformed metal to restore the stamp marks, whereas for the magnetic technique, restoration depends upon the difference in magnetic permeability between deformed and undeformed regions of a magnetic material [*1*].

Experimental Procedure

Stamp marks consisting of letters, numbers, and symbols were put on a number of plain carbon steels, ranging in carbon content from 0.04 to 0.52% C and having a ferrite-pearlite microstructure. The size of the stamp marks generally used was 2.5 mm (3/32 in.). However, the effect of stamp size on the depth of restoration was also investigated, covering stamp marks 3 and 5 mm (1/8 and 3/16 in.) in size. Stamp marks that were over 20 years old were also tested for restoration. However, unless otherwise stated, the results are for new stamp marks.

The depth of the stamp mark was determined by measuring the thickness of the material before and after the stamp mark was removed by abrading on silicon carbide abrasive papers. The depths of restoration were determined in the following way. In some cases, it was apparent that the depth of restoration had been reached as the stamp mark could just be identified. In other cases, the depth of restoration was not quite as clear-cut. A depth would be reached where the stamp mark could not be restored, whereas at the previous depth the stamp mark though becoming diffuse was restored; the mean of these two depths was taken as the depth of restoration. The incremental increase in depth between successive restorations was, near the depth of restoration, of the order of 0.13 mm (0.005 in.); therefore, in these cases the depth of restoration could be estimated within about 0.07 mm (0.003 in.).

Etching Technique

A number of different etchants were tried, namely, nital, picral, ammonium persulphate, acidified potassium dichromate, sodium bisulphite, and Fry's reagent [2]. Fry's reagent was superior and three compositional variations [2] were compared. The one selected as being most sensitive in the restoration of stamp marks consisted of 90 g of cupric chloride ($CuCl_2$), 120 mL of hydrochloric acid (HCl), and 100 mL of distilled water (H_2O). The procedure used for etching was a modified version of one previously developed [3], and consisted of the following:

chemical polish	→	distilled water	→	dilute HCl	→	Fry's reagent	→	alcohol
H_2O_2 60 mL		quick wash		50% HCl		90 g $CuCl_2$		observe
H_2O 140 mL				50% H_2O		120 mL HCl		under
HF 10 mL						100 mL H_2O		alcohol

Before specimens were subjected to the etching procedure, they were abraded down to the required depth below the bottom of the stamp mark on a series of silicon carbide abrasive papers of increasing fineness, finishing on worn 1200P grade or a 4- to 8-μm diamond polishing pad. The purpose of the chemical polish is to remove the deformed surface layers produced by this abrasion or polishing, and thus increase the sensitivity of the etching technique. After the chemical polish, the specimens were washed in distilled water to remove the chemical polish before being immersed in dilute HCl. The dilute HCl activates the surface before etching. Specimens were not etched for a fixed time, but were inspected at frequent intervals, without removing them from the etchant, for evidence of restoration of the stamp marks. After etching, specimens were washed in alcohol rather than water to prevent copper precipitating on the surface; they were observed under alcohol, because in air the surface tarnished, making identification of the stamp mark more difficult.

Magnetic Technique

Specimens used for restoration by the magnetic technique were in the form of flat strips 1 to 2.5 mm (0.040 to 0.10 in.) thick. The surface on which restoration was to occur was finished on 1200P grade silicon carbide abrasive paper, as finer finishes, namely, 4- to 8-μm diamond polish or a chemical polish, did not increase the sensitivity of the technique. The specimen was placed between or across the poles of a magnet, so that the area of concern was centered between the two poles. Magnaflux ink (iron oxide + kerosene + 5% stearic acid) was applied to the specimen, the iron oxide particles being dispersed across the surface with a vibrator where they were attracted to the deformed areas [1]. Both an adjustable electromagnet (refer Fig. 5) with full-wave rectified current and a small horseshoe permanent magnet (refer Fig. 6) were used, the strength of the permanent magnet being adjusted by placing steel spacers across from one pole to the other. The permanent magnet in most cases gave the better results.

Results

Etching Technique

An example of restoration using the etching technique is shown in Fig. 2. This specimen had been abraded down to ~ 0.05 mm (0.002 in.) below the stamp mark N; the stamp mark MK2 adjacent to it was of similar depth and had been overpunched with a center punch to prevent its identification. The stamp mark N was clearly restored, and close examination of the overpunched region revealed that the MK2 was also restored between the punch marks.

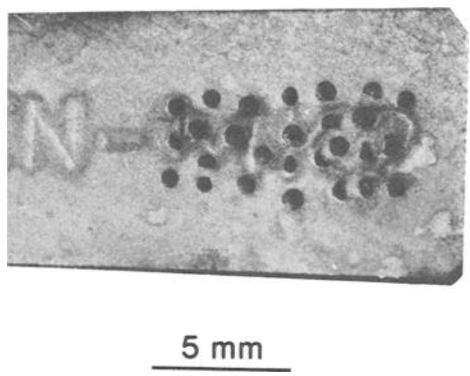

FIG. 2—*Example showing that the stamp mark* N *is clearly restored.* MK2 *can also be distinguished in the overpunched region. 0.10% C steel, Fry's reagent.*

The relation between the depth of the stamp mark and the depth of restoration is given in Fig. 3. There is some scatter in the experimental points; the curve is therefore drawn through the lower locus of the points to give the maximum depths of restoration which can be expected. Furthermore, most of the points on or near the lower locus curve were accurately determined in that they were not obtained by averaging. From Fig. 3 it is apparent that the depth of restoration increases with increasing depth of the stamp mark. This increase, however, is not linear; for stamp marks of small depth, the depth of restoration is proportionally greater. This effect is shown more clearly in Fig. 4, where the ratio of the depth of restoration to the depth of the stamp mark (B/A ratio) is plotted against the depth of the stamp mark. For stamp marks of small depth (for example, 0.1 mm [0.004 in.]) the B/A ratio is 4 to 5, whereas for large depths of stamp mark (for example, 0.4 mm [0.016 in.]) the B/A ratio is about 2.

Depths of restoration also varied with size of the stamp marks. Checks with 3- and 5-mm (1/8- and 3/16-in.) size stamp marks showed that in some cases the depths of restoration were up to 15 and 40% greater, respectively, than the depths given by the curve in Fig. 3 for 2.5-mm (3/32-in.) size stamp marks.

For stamp marks over 20 years old, the depths of restoration were similar to those determined for new stamp marks.

Magnetic Technique

An example of stamp mark restoration on a steel specimen containing 0.33% C and examined just below the bottom of the stamp mark using both the electromagnet and permanent magnet is shown in Figs. 5 and 6, respectively. A photograph at higher magnification of the restored numbers using the permanent magnet is shown in Fig. 7. Here, it is clearly apparent that the iron oxide particles are attracted to the plastically deformed regions. Since the permanent magnet generally gave the better results, it was used to establish the relation between the depth of the stamp marks and the depth of restoration (Fig. 8). The curve determined previously for etching (Fig. 3) is also shown for comparison in Fig. 8.

As with the results obtained by etching, there is some scatter in experimental points for the magnetic technique. Hence, in some cases there was good agreement between the two tech-

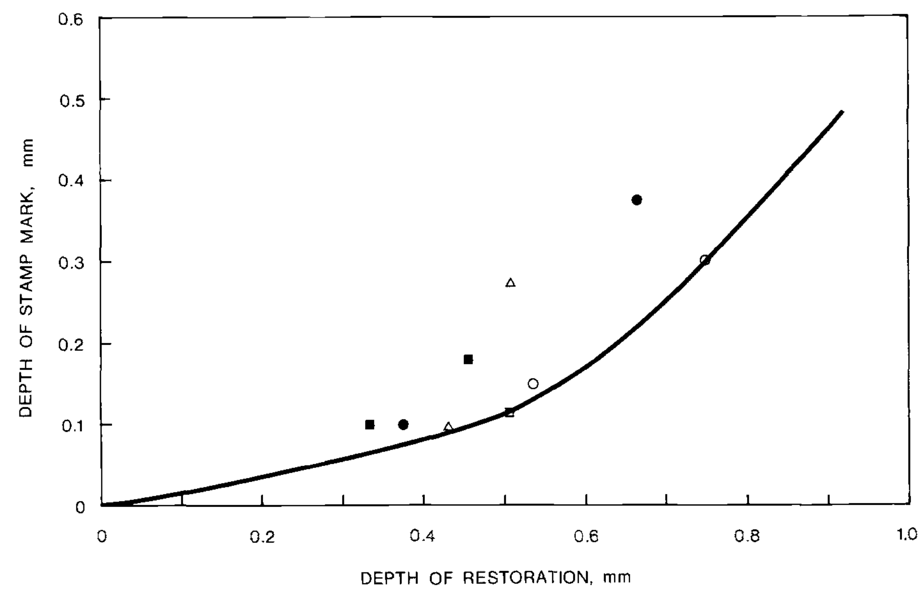

FIG. 3—*Relation between depth of stamp mark and depth of restoration. Determined by etching technique—Fry's reagent. Size of stamp marks 2.5 mm (3/32 in.).*

New stamp marks ○ *0.04% C,* ● *0.33% C.*
Old stamp marks □ *0.04% C,* △ *0.10% C,* ■ *0.23% C.*

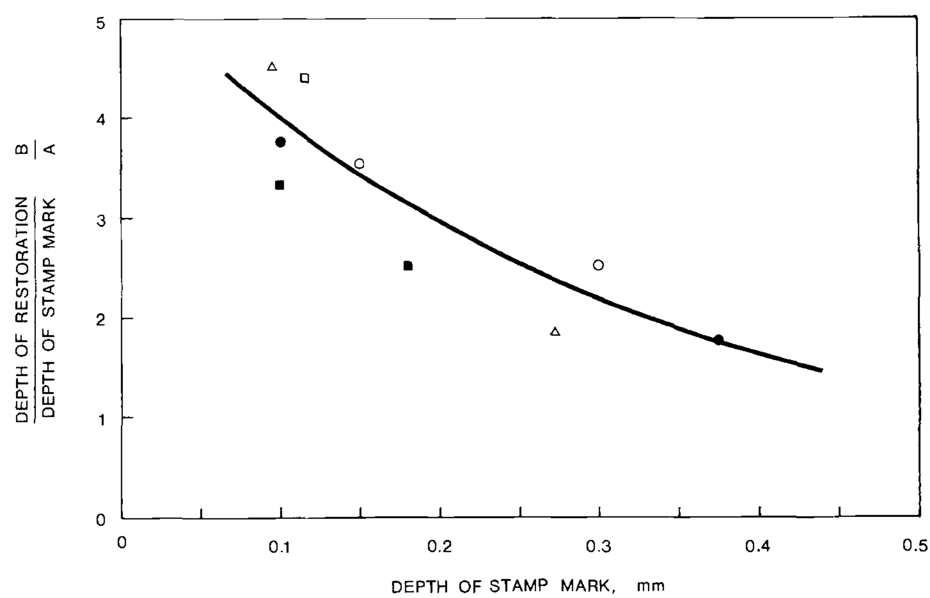

FIG. 4—*Relation between ratio of depth of restoration to depth of stamp mark and depth of stamp mark. Size of stamp marks 2.5 mm (3/32 in.).*

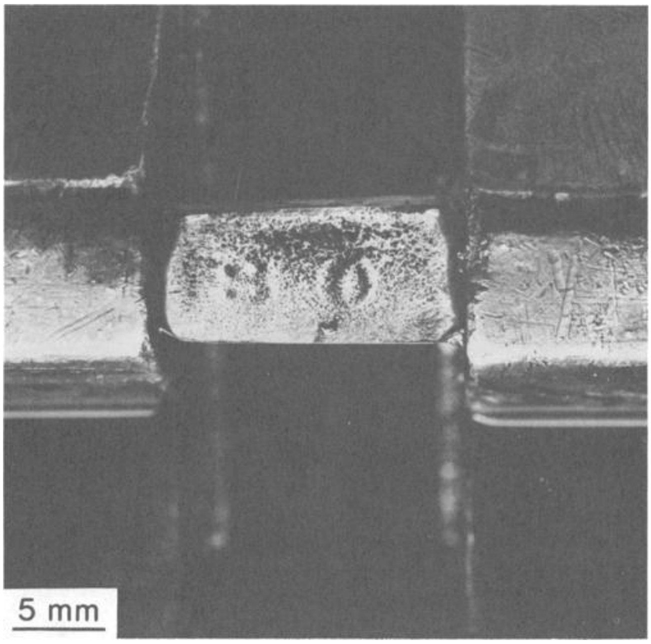

FIG. 5—*Example of stamp mark restoration using an electromagnet (0.33% C steel). The number* 80 *can be clearly seen.*

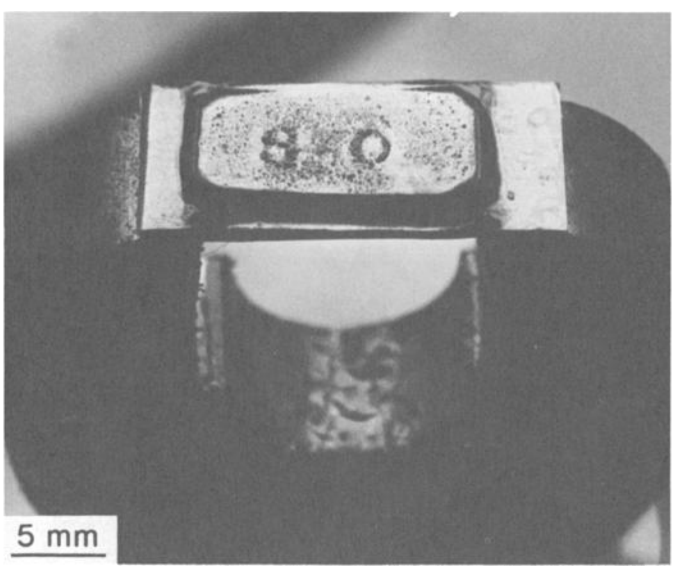

FIG. 6—*Example of stamp mark restoration using a permanent magnet (same specimen as for Fig. 5).*

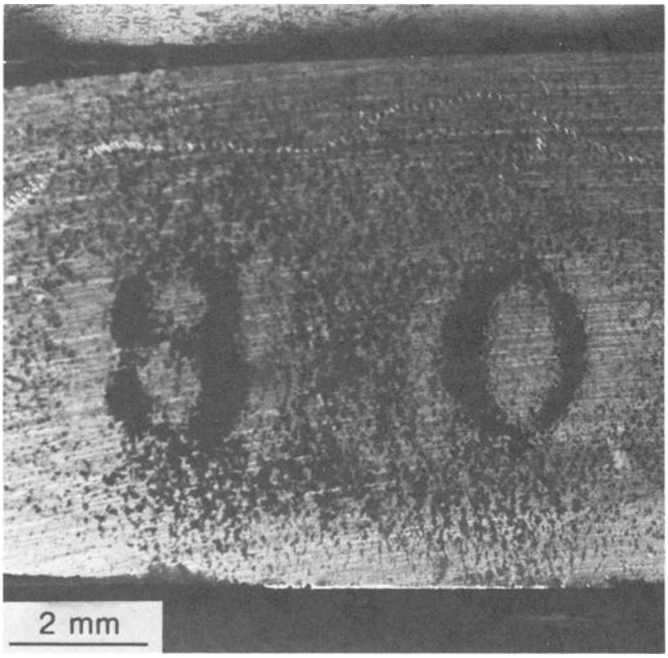

FIG. 7—*Restored stamp mark shown in Fig. 6 at higher magnification. The iron oxide particles are clearly attracted to the deformed regions.*

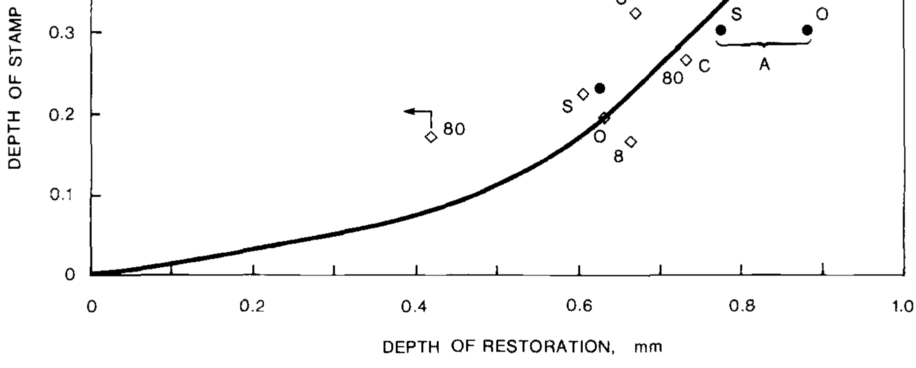

FIG. 8—*Relation between depth of stamp mark and depth of restoration for new stamp marks. Determined by magnetic technique. + 0.04% C, ● 0.33% C, ◇ 0.52% C, steel. Size of stamp marks 2.5 mm (3/32 in.). The solid curve is the relation obtained in Fig. 3 using Fry's reagent.*

niques, for example, for the stamp mark 80 (designated C in Fig. 8), whereas in others the depth of restoration was either less than for etching, for example, for the stamp marks OS (designated B in Fig. 8), or greater, for example, for the stamp mark O (designated A in Fig. 8). In this latter case, however, the depth of restoration for the stamp mark S (also designated A in Fig. 8), which was stamped next to the letter O, is similar to that obtained by etching). Overall, it is apparent from Fig. 8 that if a curve was drawn through the lower locus of experimental points for the magnetic technique, the depths of restoration would be about 10% greater than those obtained for etching. However, the magnetic technique could not restore stamp marks which had been overpunched, and for the example shown in Fig. 2, the MK2 could not be restored.

For new stamp marks, increasing the size of the stamp mark to 3 and 5 mm (1/8 and 3/16 in.) resulted in the depths of restoration being increased by up to 25 and 50%, respectively.

For stamp marks over 20 years old, the magnetic technique was much less sensitive and the depths of restoration were very much reduced, in some cases being zero. Results obtained with these old stamp marks are shown in Fig. 9, the results obtained for etching (Fig. 3) again being shown for comparison. The point designated D is a new stamp mark, which was put on beside an old stamp mark (the point designated E). The depth of restoration for this new stamp mark was determined by both the magnetic and etching techniques and found to be the same, and furthermore it was in close agreement with the previous results obtained by etching. The old stamp mark could not be restored at all. It was considered that moderate heating over the years may have caused the decrease in sensitivity using the magnetic technique. To investigate this possibility, a new stamp mark (80S) was put on the same steel and the specimen was then heated for 2 h at 200°C. The results are shown in Fig. 9, and compared with the results obtained with new stamp marks (Fig. 8), there is a decrease in sensitivity.

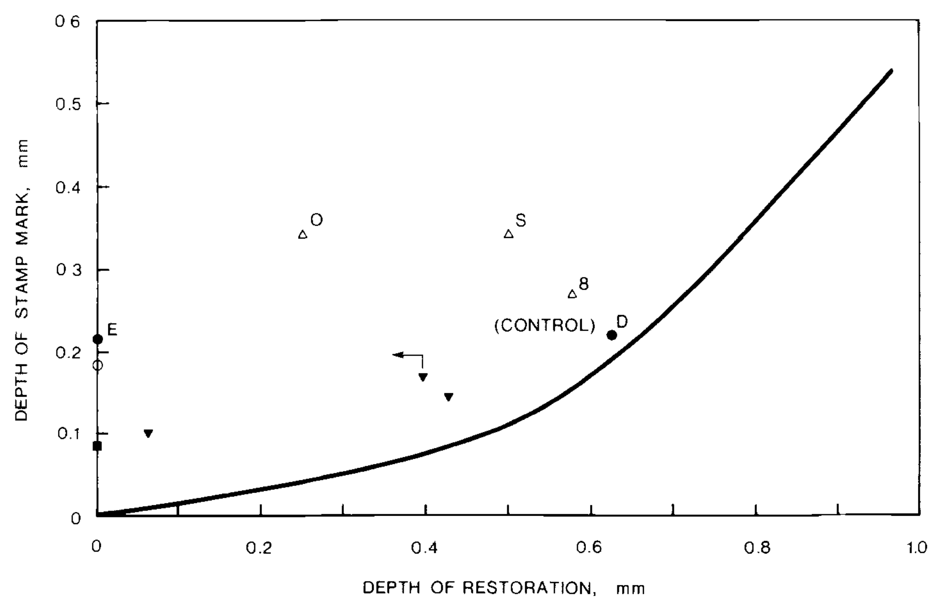

FIG. 9—*Relation between depth of stamp mark and depth of restoration for old stamp marks. Determined by magnetic technique.* ○ *0.10% C,* ● *0.33% C,* ▼ *0.11% C,* ■ *0.62% C, and specimen (*△ *0.33% C) stamped* 80S *and heated 2 h at 200°C. Size of stamp marks 2.5 mm (3/32 in.). The solid curve is the relation obtained in Fig. 3 using Fry's reagent.*

Discussion

Both the etching and magnetic techniques have been shown to be effective in restoring new stamp marks, and although there was some scatter in the results, the relation between the depth of the stamp mark and the depth of restoration could be determined. Of the two techniques, the magnetic one was the more sensitive in restoring new stamp marks, giving depths of restoration of about 10% greater than the maximum depths determined by etching. For old stamp marks (more than 20 years old), the depths of restoration determined by the magnetic technique were considerably reduced, but etching was not affected and proved to be the more sensitive technique. Though not completely conclusive, it would appear that aging or recovering effects as a result of moderate rises in temperature have decreased the sensitivity of the magnetic technique in restoring old stamp marks.

The depth of restoration did not increase linearly with depth of stamp mark; for stamp marks of small depth, the depth of restoration was proportionally greater. This result is similar to the relation previously obtained for the variation in depth of deformation with depth of cut when machining 70/30 brass [*4*]. In this case it was found that when the deformation at the sides of the cut was taken into account, the amount of which increased with increasing depth of cut, the relation between the volume deformed and depth of cut was linear. It is possible that in the present case similar considerations apply and the nonlinearity is due to the deformation at the sides of the stamp mark.

The etching technique could restore stamp marks that had been obliterated by overpunching, whereas the magnetic technique could not. The punch marks are cone-shaped, and while on the original surface they are all touching and overlapping, the diameter of the punch marks progressively decreases with depth below the surface. When the distance between the punch marks becomes appreciable, below the bottom of the stamp mark (refer Fig. 2) the stamp mark can be restored by the etching technique as the deformation zones around the punch marks are narrow. The inability of the magnetic technique to restore stamp marks between the punch marks is most likely attributable to alterations the punch marks produce in the magnetic fields.

Generally, for a given depth of stamp mark, the depth of restoration increased with size of stamp mark. This effect can be explained in the following way. The plastically deformed regions associated with different parts of the stamp mark become broader and more diffuse with increasing depth beneath the stamp mark, and in some cases, they merge and prevent the stamp mark from being restored. For larger stamp marks, this effect will occur at greater depths as the plastically deformed regions below the stamp mark are initially more widely spaced, and hence the depths of restoration will be greater. It follows from this that for a given size of stamp mark, stamp marks of simpler shape should be able to be restored to greater depths. Examination of the results in the present work, however, did not show any definite trend, and this was attributed to the scatter in the depths of restoration (refer Figs. 3 and 8).

In attempting the restoration of stamp marks, the following procedure is recommended.

The magnetic technique should be used first, because for recent stamp marks it is the more sensitive technique and it does not involve metal removal. Based on the present work, the specimen should be in the form of a flat strip, about 2.5 mm (0.10 in.) thick, which will fit between or across the poles of a permanent magnet so that the area of interest is in the center region. If the original surface upon which restoration is to take place is rough, it should be smoothed lightly with fine abrasive paper so that any deformed regions associated with the stamp mark are not removed. If the magnetic technique is at first unsuccessful, then the strength of the field passing through the specimen should be varied by using spacers or magnets of different strengths. At this stage, it would also be advisable to prepare a test specimen, made of similar material and having similar physical dimensions, which was freshly stamped with the stamp marks then being removed by abrasion. If restoration is unsuccessful, experimentation should be done with the test specimen to determine the conditions that are required, for example, the field strength can also be varied by changing the specimen thickness. When restoration has been obtained with the test specimen, but not for the unknown stamp marks under the same conditions, the etching technique should be used.

If the etching technique fails to restore the stamp marks, it is possible that the plastic deformation introduced beneath the surface, when the stamp marks were removed, was so extensive as to prevent the differential etching behavior from occurring between the deformed regions (beneath the stamp marks) and the undeformed regions (not stamped). In case a heavily deformed surface layer is present, 0.025 to 0.050 mm (0.001 to 0.002 in.) should be removed from the surface by abrading on worn 1200P grade silicon carbide abrasive paper followed by polishing on a 4- to 8-μm diamond pad. Since the response of the magnetic technique could also be affected by the presence of extensive deformation, it should be tried again first, and followed by the etching technique if unsuccessful.

If an estimate can be made of the depth of the stamp marks (for example, from similar stamp marks on other components), then from the results obtained in this study it is possible to determine whether it is feasible to restore the stamp marks. If it is concluded that the stamp mark should be readily restored, this knowledge provides a great incentive to persevere.

Acknowledgments

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References

[*1*] Wolfer, D. A. and Lee, W. J., "Application of Magnetic Principles to the Restoration of Serial Numbers," *Journal of Criminal Law, Criminology and Police Science,* Vol. 50, 1960, pp. 519-520.

[*2*] "Metallographic Reagents for Iron and Steel," *Metals Progress,* Vol. 106, No. 1, 1974, pp. 201-209.

[*3*] Bish, R. L., "A Method of Revealing Deformation in Mild Steel," *Metallography,* Vol. 11, 1978, pp. 215-218.

[*4*] Turley, D. M., "Deformed Layers Produced by Machining 70/30 Brass," *Journal of Institute of Metals,* Vol. 96, 1968, pp. 82-86.

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