The GOLDSMITHS' Company

TECHNICAL
— Journal

TOOLS & EQUIPMENT

ON YOUR MARKS…THE DEVELOPMENT IN ASSAY OFFICE MARKING TECHNOLOGY

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The traditional method of applying marks which make up the hallmark is with a punch (Figure 1). While it might appear straightforward to apply such a mark nothing could be further from the truth. If the article is not supported correctly with appropriate tooling, and the amount of force used is not right, then the metal around the mark will become badly distorted or 'bruised'. Much of the intellectual property of an assay office thus rests around minimizing such bruising through effective tooling design and ensuring high skills of the marker. Most assay offices retain extensive engineering workshops and have training programs, such as apprenticeships, to ensure that skills are handed down from one generation to the next.

Figure 1: Marking with a punch. © Goldsmiths' Company Assay Office 2014

The quality of the punch clearly has a huge bearing on the final quality of the mark. Early punches were made by direct engraving onto a punch blank or by 'hobbing', the stamping of an impression on the punch blank with another punch. More consistency between batches was introduced by pantograph engraving. A pantograph engraving machine comprises two arms mechanically linked in the manner shown below (Figure 2).

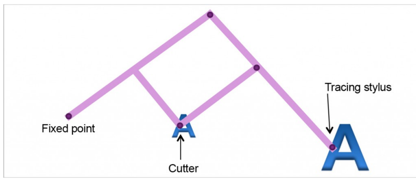


Figure 2: Principles of pantograph engraving. © Goldsmiths' Company Assay Office 2014

One arm of the machine comprises a fine stylus which traces the surface of a stencil, in this case an enlarged 'master copy' of the mark to be applied. The other arm is connected to a rotating cutting blade, which engraves a miniature but otherwise perfect copy of the master on the surface of the punch. Different sizes can be produced by changing the geometries of the arms in the pantograph. The tracing process requires considerable skill by the operator to ensure that all the detail is captured (Figure 3).

Figure 3: Engraving a punch with a pantograph. © Goldsmiths' Company Assay Office 2014

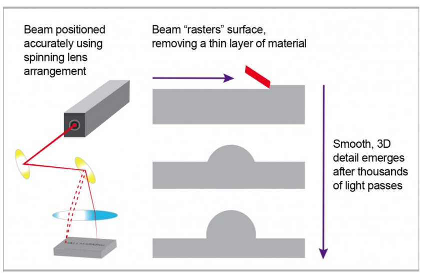
Once the engraving is completed, the 'shoulders' of the punch are filed by hand up to the edge of the shields around the mark. With shield sizes ranging from 6mm down to 0.3mm, this is another highly skilled operation.

The material used in the punches is a water-hardened 'W1 steel'. The engraving and hand finishing process are carried out in a softened state. The punch is then tempered and water quenched to harden the surface.

In the late 1990s, lasers were introduced for marking, and have had a major impact on hallmarking. Unlike punch marking where material is moved to create the desired mark impression, laser marking is an engraving process where material is removed from the surface (Figure 4).

Figure 4: Marking with a laser and examples of laser marked items. © Goldsmiths' Company Assay Office 2014

This immediately eliminates any potential for bruising, making it ideal for hollow or delicate items. It has proved highly useful for marking finished items as no remedial work or 'setting back' of bruised marks are required. Lasers can produce marks which resemble struck marks or produce outline marks that give excellent definition when applied to small articles (Figure 5).



They are also useful for applying logos or signatures.
Figure 5: Comparison of a struck mark (top), deep laser mark (middle) and outline mark (bottom). © Goldsmiths' Company Assay Office 2014
The ability to generate the detail in the engraved surface with a laser is achieved by selective removal of material in layers. If sufficiently small layers are taken, smooth, 3D features are created in the surface. The layers are removed using a fine laser beam which pulses on and off and rasters across the surface of the article (Figure 6). The rastering process is facilitated by a scan head comprising a spinning mirror arrangement.
Figure 6: Principles of 3D laser engraving. © Goldsmiths' Company Assay Office 2014
The technology used in the laser has changed significantly since lasers were first introduced for hallmarking. In particular, it is the gain medium (a crystal or optical fibre) and the source used to pump the gain medium which have changed. As each new technology has been introduced, there has been an increase in resolution and reliability. Machines have also become more compact and convenient.
The latest technology keeps the use of a diode as the source but replaces the crystal gain medium with an optical fibre doped with elements, such as ytterbium. A very stable beam is produced. Less complicated optical arrangements are necessary due to the fine diameter of the fibre, creating better resolution. Less energy is also needed as the beam is created along the long length of the fibre. Air cooling is sufficient, resulting in simpler, more compact machines. A summary of the advancement in laser technology is shown in Figure 7.
Figure 7: Advances in laser technology used for hallmarking. © Goldsmiths' Company Assay Office 2014
Once the use of lasers had been established for marking, it seemed an obvious step to use the technology for punch making. However, while the principle of the etching process is the same, punch manufacture is significantly more demanding than for marking. The designs for punches are more complicated because a 'release angle' needs to be incorporated to allow the punch to be removed easily after striking the article. In addition, the finish of the 3D features in the etched surface must be considerably smoother as the slightest amount of roughness will 'pull out material' when the punch is removed. There must also be no residual or re-deposited etched material (recast) trapped in the details.
Lasers used for punches must have higher layer depth control as many more passes need to be given to create the smoothest features. Also, as there are more layers, greater control of the beam profile and pulse frequencies are required to ensure the correct power is given to remove sufficient material, while preventing excessive melting of the surface (which reduces resolution) and to prevent recast.
The manufacture of punches using laser technology is still in its infancy but the key steps in the method are:

Figure 8: 3D image of leopard's head designed in Artcam software. © Goldsmiths' Company Assay Office 2014
1. 3D image design (Figure 8). This can be done either by a 3D scan of a master copy of the mark to be applied or direct design in suitable 3D design software, such as Artcam or Type 3. A combination of the two is often used. A key challenge of the design is to get the level of detail right, e.g. a detailed leopard's head may be suitable for marking at 2mm or above, but at smaller sizes the detail merges and the final mark suffers. The 3D program converts the image into a stereo lithography (STL) file, a format which can be read by the laser and contains the geometry of the image.

Figure 9: View of layer to be cut on laser control software. © Goldsmiths' Company Assay Office 2014
2. Laser set up (Figure 9). The STL file is loaded into the laser which interprets the data and calculates the number of passes that should be applied. The calculation is based on previous calibrations on the material used. The best resolution for a smooth finish is often found to be around half the beam width per layer step.

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Figure 10: Positioning laser used to locate image to be etched on punch. © Goldsmiths' Company Assay Office 2014

3. Insertion of the punch blank. The size of the surface of the punch blank is chosen to be as near as possible to the size of the mark. This minimizes the amount of later finishing. The surface of the punch blank is required to be polished. A visible light positioning laser is used to align the punch blank correctly (Figure 10).

4. Etching. A two letter, 0.5mm high sponsor's mark takes 57 minutes to cut over 1200 layers. Multiple stations on the laser allow several punches to be cut in sequence.

Figure 11: Finished punch. © Goldsmiths' Company Assay Office 2014

5. Finishing and hardening (Figure 11). The punch is hand finished and hardened. It has been found that a key benefit of using laser technology for punch making is that the resolution is significantly better on punches with marks below 1mm shield size. This is because the width of a laser beam is much finer than the radius of the point on a mechanical cutter.

In summary, it could be said that the hallmarking process is carried out by lasers because lasers are used for both marking directly and the making of punches! The question that could be asked is why laser marking is not used for hallmarking all articles. Indeed, it is in some countries which have recently introduced hallmarking systems. However, in the UK, uptake has been no more than around 20% of all items hallmarked. This is because customers still like the association of hand crafted quality that striking a mark with a punch entails - the marks on any two articles are never quite the same, making each article unique.