WHITE PAPER – **STAMPER PUNCHING**

As the density and speed of the Optical Disc increases, especially with Blu-Ray, it becomes more and more critical to accurately replicate the pit structure in the moulding process. In turn, this places greater demand on punching techniques, and an even greater emphasis on the need for correct specifications of stamper geometry, physical makeup and characteristics.

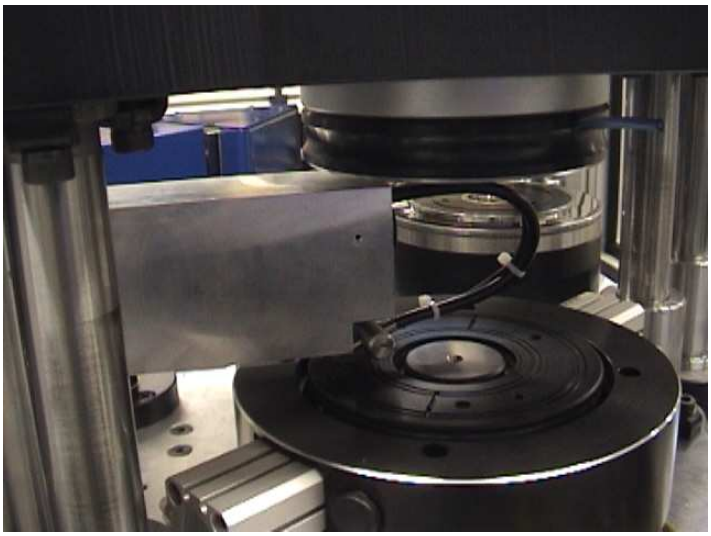
In the strive for the optimum punched stamper, five key critical features must be examined. For some time there has been a focus on the **Punched Hole Size** and **Punched Hole Roundness**, along with the **ECC** required, but increasingly there is a focus on **Punched Hole Geometry** and **Stamper Deformation**. Quality of cut is also a key factor in optimum moulding performance; this is largely dependant on **Punch & Die Lifetime.**

This article looks at each criteria in turn as follows: -

- **Punched Hole Size**
- **Punched hole Roundness**
- **ECC**
- **Punched Hole Geometry**
- **Stamper Deformation**
- **Punch & Die Lifetime**

The **Punched Hole size** is controlled by the punch & die cutting parts and also greatly influenced by stamper properties. Historically a 10 micron tolerance band was specified, but this window is now being reduced to 5 microns and even below, in the strive for greater accuracy. The size is controlled by two factors; the punch cutting diameter and the correct clearance between the cutting parts. This clearance is carefully calculated taking into account the thickness of material being punched, which must also include the protective coating being used. Any change therefore in thickness of stamper or protective layer will influence the end result. Stamper hardness will affect the result; normally a harder stamper will produce a smaller hole, but due to other stamper physical properties there are exceptions to this rule. As the cutting parts wear the hole size will typically decrease by a few microns so, as with any cutting tool, regular maintainance is essential to maintain correct specifications.

Control over **Punched Hole Size** can be improved by punching the ID hole as a separate operation. In a combined ID/OD setup, the ID cutting part remains in the stamper centre hole during the OD punching operation, potentially influencing the punched ID hole. By separating the ID & OD punching procedure this effect can be completely eliminated.



Separate ID & OD Punch & Die sets in SPS - Punch

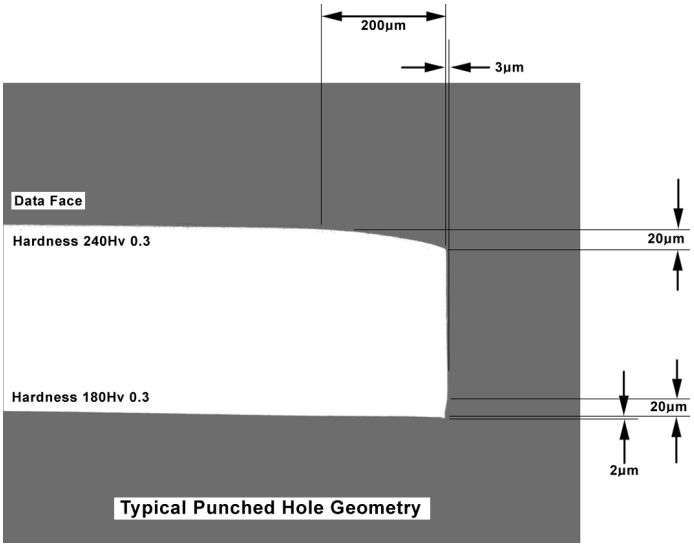
Punched Hole Roundness is another key area that must be controlled. The roundness of the punched hole is mainly controlled by the accuracy of alignment between the lower part, the die, and the upper part, the punch. Any misalignment between the punch & die will create an oval hole. Unroundness in the punched hole will influence ECC on the polycarbonate disc during replication, along with other issues involving excessive stamper movement on the mirror face.

With the introduction of an improved alignment system, the use of a removable alignment tool has been removed. A sprung loaded ID Die stripper also incorporates an alignment 'V' for greater accuracy. This part remains fixed in the tool thus eliminating any error during fixing and maintaining optimum **Punched Hole Roundness**.

The **ECC** of punched hole in relation to data is imperative for optimum quality of replicated disc. The **ECC** between data and punched hole is controlled by the alignment of the stamper in the punching equipment, and the accuracy of the cutting parts within the punch & die assemblies. Historically a tolerance of 20 microns was acceptable, but once again in the strive for greater density, this accuracy must be improved. ECC to 5 microns and below is typically being requested which in turn places even greater demands on the punching and alignment systems being employed. When trying to achieve **ECC** values at 5 microns and below it is imperative that the data band is round to within 2 microns, and that the punch and dies are perfectly aligned in the equipment.

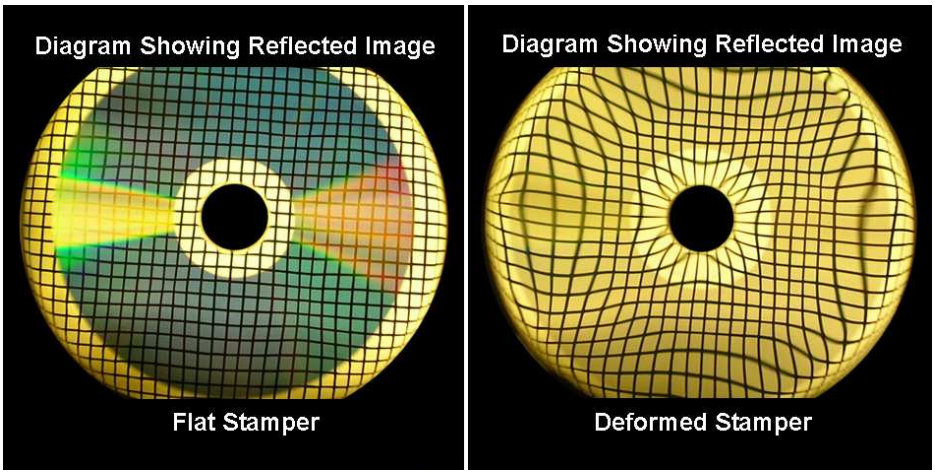
Improved **ECC** can be achieved by the upgraded punch & die alignment system. The alignment tool remains in the assembly thus eliminating the chance of error during punch & die change. Enhanced optics with improved illumination creates an improved image contrast, which in turn allows the image capture software to track the data band more efficiently.

A relatively new focus is on **Punched Hole Geometry**. Due to the process of punching there is always a small deformation around the ID hole at the punch entry point. This deformation area can be greatly influenced by a) Tool wear b) Stamper hardness c) Punch & die clearance d) Protective coating material and thickness. A blunt punch & die set will create a greater deformation, whilst a hard stamper will reduce this. Punch & die clearance has to be carefully controlled as excessive clearance will create a large deformation as the material pulls into the hole. The protective coating used on the data face can create a large deformation area, as it acts like a soft membrane between the nickel stamper and the hardened punch & die set. Excessive deformation, or punch entry radius can potentially cause damage to the stamper holder in the mould. Due to the very high moulding pressure used, ingress of polycarbonate behind the stamper will break the lip of the stamper holder. In addition, the moulded polycarbonate disc will not separate cleanly as it will tend to 'grab' to the centre of the stamper holder. This is also a critical factor for DVD manufacture, as any lip formed on the polycarbonate disc can create bonding issues.



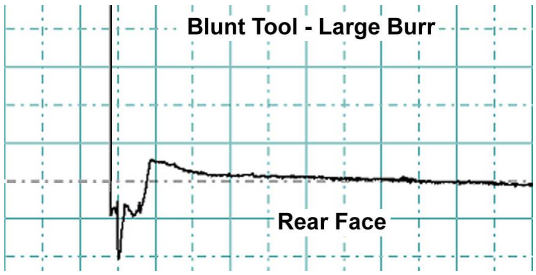
It has been proven that punching with protective coating, where the ID area is clear, can create the optimum **Punched Hole Geometry**. This has the benefit of the centre area being clear whilst the data area remains protected. A simple hand-held application device can be used for aligning both the stamper and the pre-punched tape.

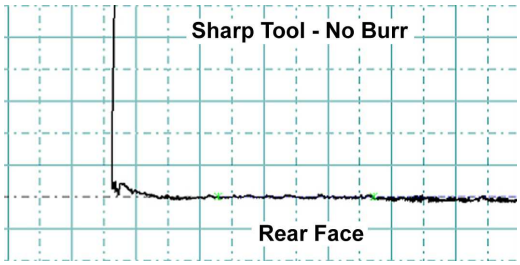
Due to the forces required during the punching process, the stamper is subjected to a lot of pressure. If not carefully controlled, this pressure can create excessive **Stamper Deformation,** which can take the form of either a localised dent or crease or an overall unflatness of the stamper after punching. This feature can greatly affect the clamping of the stamper in the mould, therefore potentially creating issues during moulding. Stamper flatness during punching is carefully controlled with the use of sprung loaded stripper plates and carefully designed heights of relative cutting and stamper support faces.



By separation of ID and OD punch & die sets, a larger vacuum clamping area can be used to hold the stamper flat during punching. The critical relationship of heights between ID and OD cutting tools is also removed, thus allowing the stamper to remain flat during the punching operation. Independant stripper plates for both ID and OD also assist in reducing **Stamper Deformation.**

Once the optimum punch & die set up has been achieved, the quality of the punched stamper will be maintained provided the cutting edges remain sharp. The **Punch & Die Lifetime** is affected by the hardness and thickness of the material being punched as well as the accuracy of alignment between the punch & die cutting faces. Regular maintainance and cleaning will help increase the life of the cutting edge, thus allowing the optimum punched stamper results to be produced over an increased period of time.





Although the hardness of the stamper is controlled by electroforming, the hardness of the punch & die cutting faces can be increased by up to five times using Titanium Nitride (Tin) coating. This will greatly increase **Punch & Die Lifetime,** and lengthen the time required between punch & die maintenance.