Micro Electro-Discharge Machining (Micro EDM)

1. EDM-Brief description

Electro-discharge machining (hereafter referred to as EDM) is a machining technique that has been around in industry for many decades. It is well understood from an application point of view and well characterised for larger components. It is not so well characterised for micro work and each process requires a significant amount of process optimisation. All EDM techniques use the principle of creating electrical sparks between an electrode and the work-piece. A voltage difference is applied between the work-piece, which has to be electrically conducting or semiconducting, and the electrode. When the voltage is high enough, an electrical discharge takes place which generates heat in either the work-piece or the electrode and often both. The heat generated is very intense, very localised and of a very short duration and causes a very small spot on the work-piece and often the electrode to melt or evaporate. This creates a small crater or pit in the work-piece and by repeated pitting, the shape of the electrode is eroded into the work piece. There are two main types of EDM used frequently: volume EDM and wire EDM.

2.1 Volume EDM

Volume EDM uses a solid shape electrode which is the counterpart of the material to be removed in the part. Volume EDM is very useful for drilling deep holes and slots and complex shaped cavities of very high aspect ratio (feature depth to width ratio). Micro EDM processes can be used for milling by moving the part in the X Y direction. A micro EDM electrode for drilling holes is shown in Figure 1.

Figure 1 showing EDM electrode. Minimum diameter is 6 microns.

2.2 Wire EDM

Wire EDM uses a continuously running thin wire as the electrode and this is very useful for cutting profiles in plates, see Figure 2.

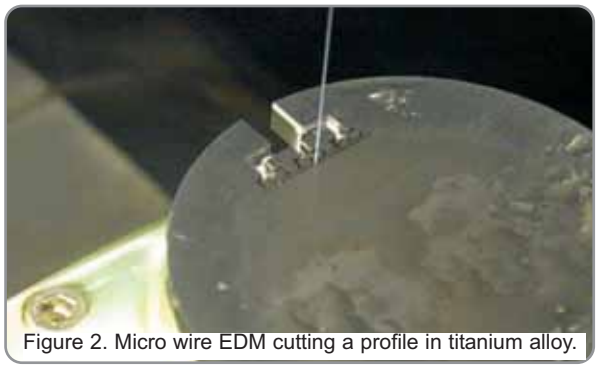


Figure 2. Micro wire EDM cutting a profile in titanium alloy.

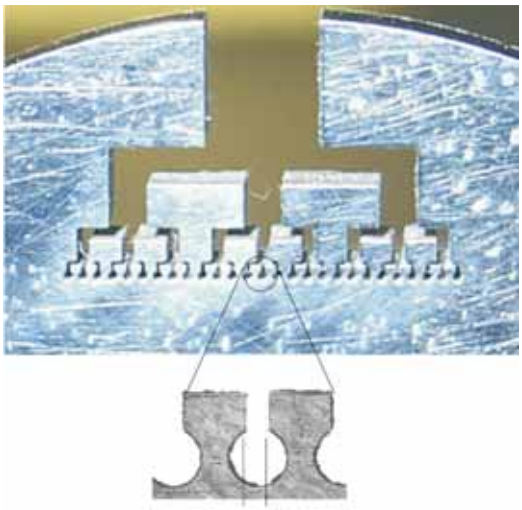
EDM uses electrodes made from many different materials and copper, beryllium copper, graphite, brass, tungsten, and tungsten carbide are examples. Wire EDM often uses a steel wire that has been coated with brass, tungsten wire and other materials of good conductivity, high strength and high melt point. The electrode material has to be matched to the work piece material so that in-process variations are controlled effectively. This is critical for achieving micron tolerances, especially when the spark gap can be as big as 30 microns.

Micro wire EDM is particularly suited to making small parts with very tight tolerances and with good quality surfaces finishes. Dual micro wire EDM machines use two wires of different diameters and the finest wire that can generally be used is 20 microns diameter but 30 micron wire is more frequently used because it is a little easier to handle.

3 The advantages and usage

The main advantage of micro EDM is the versatility of the process and the shapes that can be produced. It is also very useful for machining and producing very small and delicate parts as the process is effectively non-contact. The wire does not touch the surface so there should be no lateral forces on the part and as it is a thermal process micro EDM is excellent for machining very hard substances such as hardened carbon steels or tungsten carbide or difficult to machine metals such as titanium.

EDM is used for many applications and is used extensively for making one-off or small batches of very small parts in specialist steels which make it ideal for medical applications. It is also very useful for manufacturing micro injection mould tools, especially for high production volume polymer parts. One medical application is shown in Figure 3.



135 microns.

Figure 3 Micro fluidics mixer used for mixing medical reagents in an analysis instrument. Minimum channel width 135 microns.

The micro channels have a high surface to volume ratio which helps create turbulence and hence stirring of the chemicals. Many fluidics devices can be generated using micro EDM techniques.

Conventional micro machining and milling techniques use very small cutters for physical removal of material. These are very good for certain micro applications where the aspect ratio is low, typically of the order of 1 or 2 and the minimum feature thickness required is not less than 30 or 40 microns. Where the EDM process is very useful,
especially wire EDM, is for making very high aspect ratio features. Holes of 200 microns diameter and 6 mm deep are possible and
electrodes of very high aspect ratio, such as 20 micron diameter and 2 mm long are possible. However, these also are characterised by having a limited aspect ratio especially where very small holes or slots are concerned.

4. Conclusion

Micro EDM is a very useful tool for machining micro features and parts of down to a few microns in size with high aspect ratio in many different conductive and semiconductive materials.

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