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TECHNICAL NOTE

# *The use of electrochemical machining in biomedical engineering*

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Electrochemical machining (ECM) is a form of accelerated corrosion [1]. The anode of an electrolytic cell is caused to dissolve at a high rate by the passage of currents frequently in excess of $10^6$ $Am^{-2}$ and by the use of high electrolyte flow rates. Flows of 50 $ms^{-1}$ through gaps between the electrodes of less than 0·5 mm are normal. ECM has many advantages over conventional methods of machining: for example, the shape of the finished article is generally no restriction on the technique – hexagonal, elliptical or any other shape of hole may readily be produced; the hardness of the material is of little consequence – all metals will dissolve in accordance with Faradays laws and consequently the technique may be applied to the machining of steels, nimonics, titanium alloys (even to tungsten carbide composites) etc.; rates of removal may be orders of magnitude higher than for conventional machining methods [2]. Applications include the machining of turbine blades [3] and the manufacture of machine-tool dies [4].

Amongst the disadvantages of the technique may be cited the problem of machining sharp corners. With ECM it is difficult to avoid a radius on a corner or edge of at least 0.1 mm; this in some cases may be regarded as unacceptable but in other cases may be desirable because it brings about a certain strengthening and chip resistance. In view of this, ECM seems to have particular potential in the deburring of gears [5].

Nevertheless, engineers and tool operators generally appear loath to apply electrochemical techniques to machining problems; however a number of specialist applications are envisaged, e.g. in the field of biomedical engineering, in addition to the aerospace industry where one already finds a considerable activity. Pins, plates and artificial joints, for example, and a number of other metallic body-inserts must be meticulously engineered [6], and in the case of titanium and its alloys is preferably also anodised in order to aid body compatibility. Electrochemical machining will both machine and anodise in a single process. Fig. 1 shows a part-machined stainless steel plate for use in bone surgery. The egg-shaped and tapered holes have been produced by a single operation in only a few seconds using a 15% NaC aqueous electrolyte. The electrode gap was kept at 0·2–0·4 mm and the flow rate at 20–40 $ms^{-1}$. The formation of such holes by conventional means would be a difficult and lengthy procedure.

Electrochemical dissolution has also been applied to the technique of grinding [7]. Here the workpiece is made the anode and a conducting diamond-impregnated wheel the cathode in an electrolytic cell. Electrolyte is fed through the gap between the electrodes by the centrifugal motion of the wheel, thus it is not possible to calculate the actual electrolyte flow between the electrodes. It is though that most of the material is removed by the electrochemical processes and that the grinding serves to disrupt passive and diffusion layers. High rates of machining may be obtained with the precision of mechanical grinding. In addition the finished article will be burr free. Fig. 2 shows a Stereoscan photograph of the cutting edge of a steel spring for use in contact with intravenous injection solution. The spring has been mechanically ground on a vertical-

 

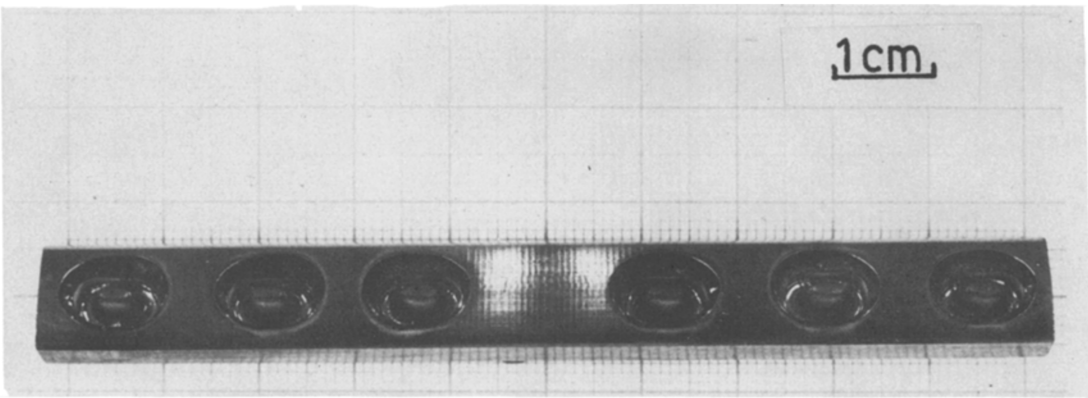


Fig. 1 Electrochemically machined plate for use in bone surgery.

spindle machine with a wheel of grit 50 (for medium hardness materials to medium finish) at a table speed of 1m $min^{-1}$ and a feed rate of 0·0125 mm per sweep. It has burrs attached which must be removed by hand.

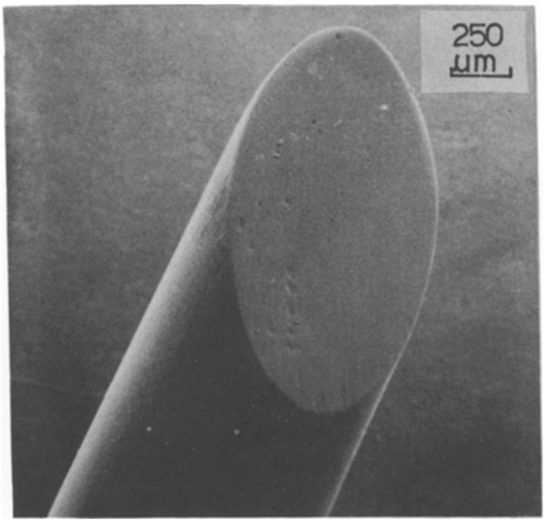


Fig. 2. Mechanically ground spring.

Fig. 3 shows a similar spring which has been electrochemically ground at twice the table speed and ten times the feed rate using 15% NaC electrolyte. The danger of metal shavings in the injection fluid is eliminated and it is estimated that the product can be produced at less than one tenth of the cost.

**Acknowledgement**

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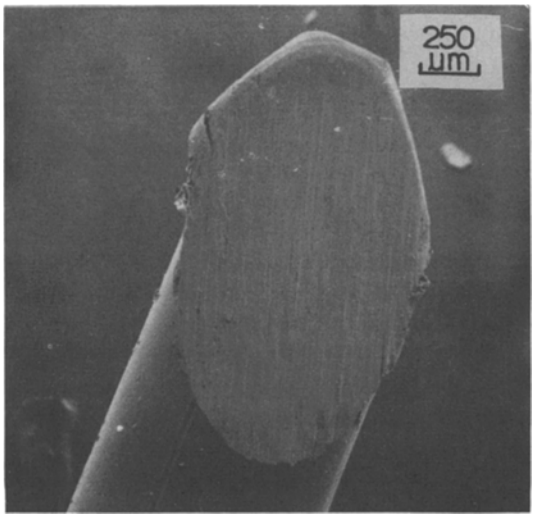


Fig. 3. Electrochemically ground spring.

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