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Compact Electro Chemical Machine Tool

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Abstract

Electro chemical machining is an effective process for machining complex features into difficult to machine materials. Traditionally, ECM machine tools have been high cost systems with significant electrolyte process services. This paper introduces the design and performance of a new cost-effective ECM machine tool. The Loxham Precision µECM machine is small, digitally integrated, easy to install, operate and maintain.

The µECM is devised to offer a rapid means to microstructure surfaces of a wide range of materials including those that are difficult to machine with conventional cutting tools. Machining performance verification is demonstrated through the fabrication of Loxham Precision's air bearing slideway components.

1 Introduction

Electrochemical machining (ECM) is a well-established process often classified as a non-conventional machining process [1, 2]. ECM removes material by an electrochemical process and as such it is limited to electrically conductive workpiece materials. Since the process is electrochemically based it is suitable for hard and difficult to machine materials including; titanium, Inconel, tungsten carbide and high nickel and cobalt based alloys.

ECM is a non-contact machining process where the tool (cathode electrode) is separated from a positive charged anode workpiece by a pressurised electrolyte. Material is removed from the workpiece without thermal or mechanical stresses. Material removal rate is electrical current density dependant and surface qualities achieved are based on a combination of workpiece material, electrode material, electrolyte type and process settings. ECM is often used for die sinking, fine hole machining, turbine finishing, deburring, etc. Micro ECM

process has recently been shown to be able to produce fine features using an electrolyte jet process and a controlled moving electrode [3]. These “moving” electrode methods offer high levels of surface shape control albeit at the expense of bulk material removal.

In contrast fixed distance shape electrode ECM is a very simple rapid means to introduce structure into surfaces whether they are difficult to machine materials or otherwise. This paper describes a cost effective ECM machine tool manufactured by Loxham Precision Limited for automated surface structuring.

2 Shape electrode ECM

Shape electrode ECM machining employs a shaped electrode surrounded by an insulating material. The shape of the electrode is that which will be machined into the workpiece surface. The surface of the electrode can be held at a fixed position from the workpiece surface either through design features of the electrode (as a simple approach for shallow features) or, by process control through current density / conductivity monitoring. For high productivity machining of shallow patterns in the 0.005 – 0.1mm range the shape electrode ECM process method has been found to be highly effective. Surface structuring at 0.25 – 5mm lateral feature size can be achieved at a rate of 20mm^2 / micrometre depth / second with a simple low current density ECM process (MRR 0.02 mm^3/sec). To cost effectively apply this shape electrode process a new Loxham Precision automated ECM machine tool had been created as described in Section 3.

3 Loxham Precision µECM

The Loxham Precision µECM is a three linear axes Cartesian CNC machine tool, Figure 1a. It is fully interlocked and contained. It can automatically operate numerous iterations of shape electrode ECM machining. The machine motions, ECM process and electrolyte conditioning system are all fully controlled via a tailored PLC controller. The machine is capable of performing a series of processing steps. In its simplest operation a dedicated single electrode can perform the same ECM process numerous times to structure surfaces, Figure 1b.

Figure 1 a. Loxham Precision µECM machine, b. Shape electrode processing

Loxham Precision µECM is equipped with a 250 Amp power supply whose output is controlled using solid state relays to achieved sharp feature fast pulses. This power supply control function enables high quality transfer fidelity and surface roughness levels to be achieved when using shape electrode ECM. A dedicated electrolyte delivery and filtration system is provided with the machine to ensure ECM processing stability is well maintained.

µECM is a highly compact machine of 1.2m (w) 0.7m (d) and 1.4m (h) yet has a workpiece surface area coverage of 500mm by 350mm.

4 µECM performance

By way of example the performance of the Loxham Precision µECM is illustrated by the machining of Loxham air bearing slideway components shown in Figure 2. These high precision bearing components demand fine features to be machined into their surfaces.

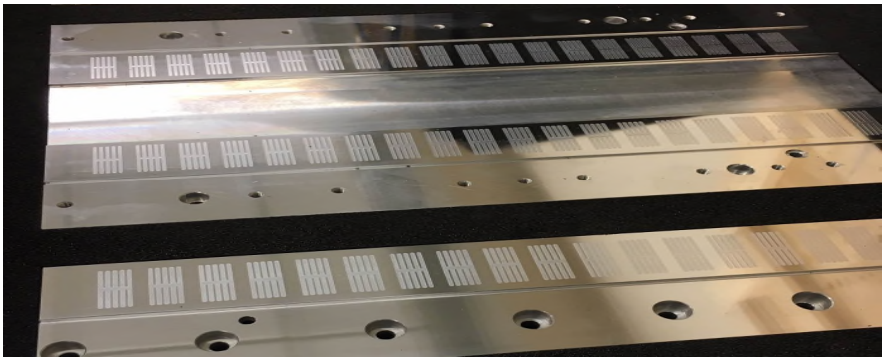

Figure 2 Loxham Precision air bearing components having µECM features

Processing time for 4 off air bearing slideway components each having tracks with 20 pattern features is less than 7 minutes. Depth control of the ECM produced features is better than +/- 0.001mm when producing 0.008mm deep patterns, see Figure 3.

5 Conclusion

This paper has briefly introduced the design and performance of a new µECM machine tool. This compact machine offers a cost effective machining technology for surface structuring of difficult to process materials. The machine is configured to be easily operated in an automated manner offering micrometre

depth control of produced features without high precision and high cost micromachining technologies.

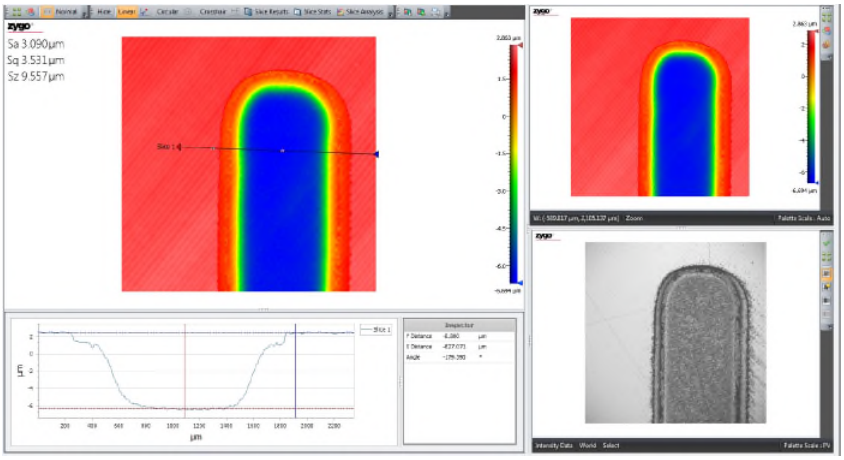

Figure 3 µECM features of Loxham Precision air bearings
(Courtesy of University of Nottingham)

This new Loxham Precision micromachining CNC machine tool hugely reduces the cost of acquiring and automating ECM processing capabilities.

References

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