Ultrasonic Assistance of Electrochemical Jet Machining: An Initial investigation in Inconel 718 (CAPE 2015)

Poster · November 2015

DOI: 10.13140/RG.2.2.33683.89123

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Ultrasonic Assistance of Electrochemical Jet Machining: An Initial Investigation

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Project Objectives:

- Investigate the influence of Ultrasonic Assistance (UA) on Electrochemical Jet Machining (EJM) of Inconel 718
- Identify the differences in the surface topography of using ultrasonic assistance compared to non-assisted
- Quantify the changes using ISO surface characterisation standards for surface roughness

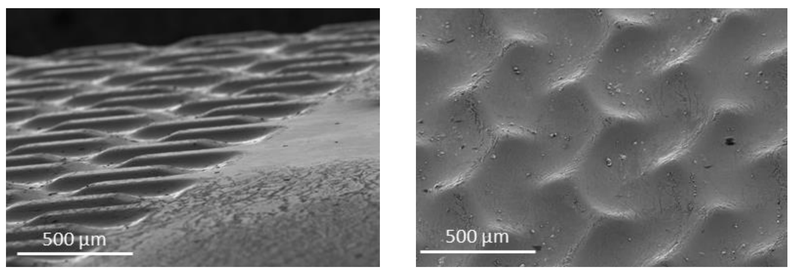

Figure1: *Typical EJM created features showing micro machining and in process surface roughness modification*

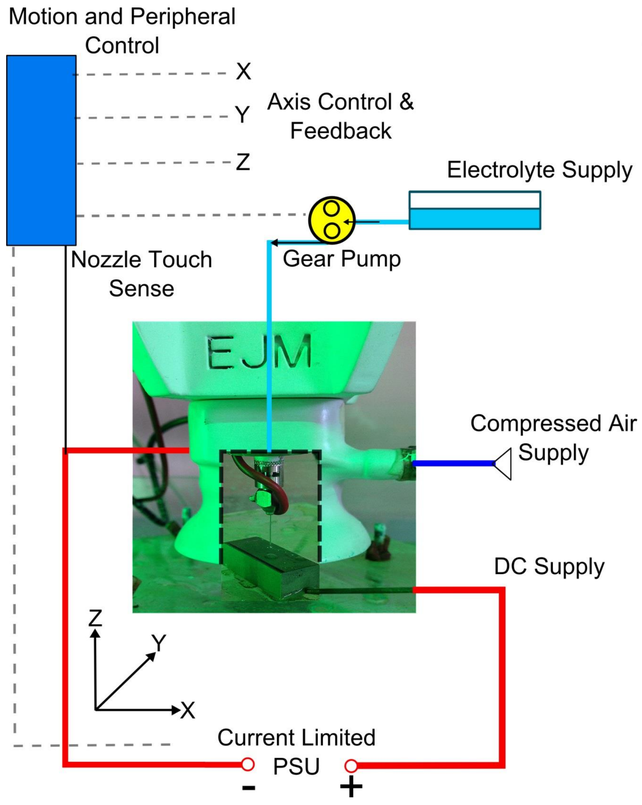

Figure2: *EJM research platform schematic*

Introduction

Electrochemical Jet Machining (EJM) is a highly localised form of electrochemical machining (ECM). Unlike ECM no specialist tooling is required instead a jet of electrolyte is utilised to selectively remove material. An electrical potential is applied between the nozzle supplying the jet (cathode) and the work-piece (anode) allowing anodic dissolution of the work-piece, the method of material removal. In EJM material removal is limited to the exposed substrate directly below the electrolyte jet therefore not requiring additional masking. This is due to confinement of the current density field in the working gap. Firstly due to the phenomena of the hydraulic jump as current density can not be developed in the thin film area surrounding the impingement zone. The second being a compressed air shroud that is directed co-axially around the nozzle which extends the thin film area and concentrates the jet so minimising current stray allowing more precise surface structuring [1] (***Figure 1***).

Ultrasonic stimulation has been widely used in non-conventional machining [2]. It is widely recognised [3] that in subtractive ECM benefits can be gained from 'de-passivation' to help remove oxide layers and sludge films thereby increasing process performance and change surface topography by reducing surface roughness.

Ultrasonics allows a relatively simplistic integration of a de-passivation system into the EJM process. With direct vibration of the anode (work-piece) this initial investigation aims to assess the effects of Ultrasonic Assistance (UA) to create alternative surface textures. These resulting surface textures being of interest to researchers working in the area of surface functionalisation and structuring.

Methodology

Initial investigations were carried out using a previously developed EJM research platform [4] (***Figure 2***) utilising a specially constructed ultrasonic stage (***Figure 3***). A single ultrasonic frequency of 40kHz was used to machine multiple striations at increasing current density (*J*) (50, 200 and 300 A/cm²) in Inconel 718. All other parameters remained constant throughout: Nozzle Stand off: 0.5mm, Nozzle traverse speed: 0.5mm/sec, pump flow rate at 60ml/min and the electrolyte of 3 mole concentration of Sodium Nitrate. Sample patches were then imaged along the length of each track and analysed to obtain surface characterisation.

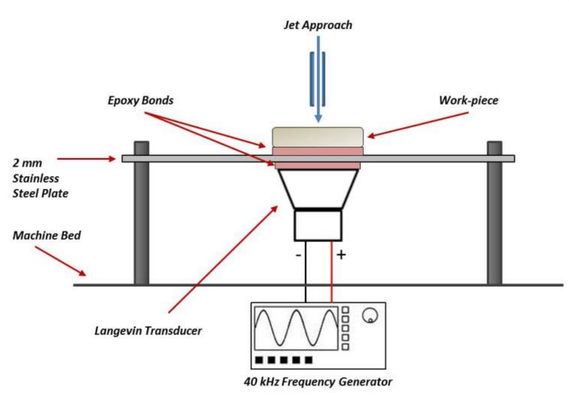

Figure 3*: Schematic of Ultrasonic stage arrangement*

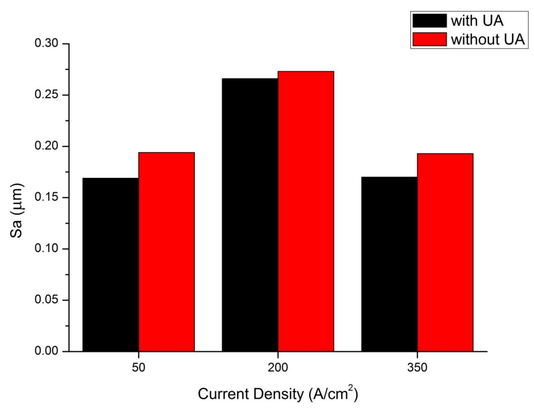

Figure 4: *Results of UA on surface roughness (Sa) across a range of current densities*

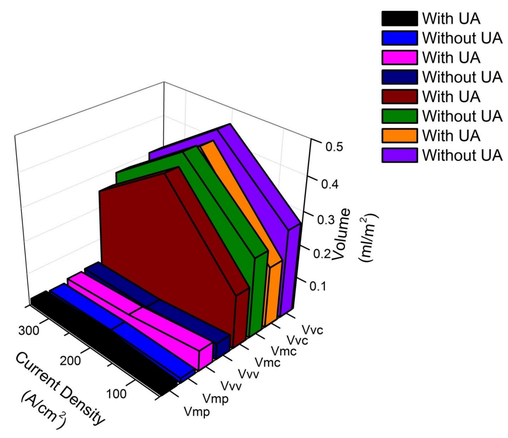

Figure 5*: Results of using UA on Volume parameters found within the surface topography across a range of J*

Results

Significant differences were found between assisted and none assisted surface topographies. The use of UA-EJM shows a reduction in surface roughness averaging 9% demonstrated by the lower achieved Sa values across all three current density values (***Figure 4***). *J* Has been found previously to be the main parameter for controlling surface finish [5]. This is supported by the change in mean values of the volume parameters as defined in ISO 25178 3D between Ultrasonically Assisted (UA) and non assisted showing variance in the mass of material found in the valley (Vvv), core (Vvc and Vmc) and peak (Vmp) regions of the surface topography (***Figure 5***).

Conclusions

From this initial investigation these conclusions were found:

- Surface roughness can be reduced in Inconel 718 by on average 9% across a variation of current densities with the use of Ultrasonic Assistance compared to surface geometry created by EJM without assistance.
- The use of Ultrasonic Assistance demonstrates the ability to create alternative characteristics found in the surface topography.
- Further research is required across a variety of materials and ultrasonic frequencies to asses the frequency response on the surface topography.

References

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Acknowledgements:

Authors would like to acknowledge EPSRC for supporting this work through EP/M02072X/1 "In Jet Interferometry for Ultra Precise Electrolyte Jet Machining".