

Design and Performance Analysis of Electrochemical Micro Machining on GI Sheet

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Abstract- Galvanized iron is manufactured and used for wide variety of purposes but its primary use is for sheet metal roofing and other building materials, such as metal framing studs, metal roof shingles and fencing. It may be used in future as micro level applications on the field of science and Nano technology. The current techniques for micro manufacturing mostly are silicon based. These manufacturing techniques are not suitable for use in demanding applications like aerospace and biomedical industries. Electrochemical micromachining (ECMM) can machine hard metals and alloys at micrometer scale. So, we developed a cost efficient electrochemical micromachining with feed control setup and conduct a performance analysis of electrochemical micromachining on GI sheet to find out the efficient parameters value required for GI sheet to perform a micro hole in electrochemical micromachining.

Index Terms-Spiral baffles, Helical coil spring, Double pipe heat exchanger, Overall heat transfer coefficient, Pressure drop.

I. INTRODUCTION

Material removal techniques have a pivotal role to play in component fabrication. In recent years many high strength alloys such as copper beryllium and titanium alloys were produced that are extremely difficult to machine using the traditional processes. These alloys were developed for a variety of industries ranging from aerospace to medical engineering. Machining these alloys with conventional tools results in subsurface damage of the work piece and in tool damage. The tool size and geometry limit the final component shape that can be machined. Another problem with these tools is that they tend to leave burrs on the machined surface. These burrs are undesirable in many applications. For example, in the medical industry the presence of even very small burrs will damage living tissues where these machined parts are used as implants. In electronic devices where a number of components are in close contact, the burrs may lead to short circuits. In mechanical components burrs may result in a misfit. Electrochemical machining (ECM) can machine these alloys.

Devices are becoming smaller as time progresses but their features are increasing at the same time. Machining materials on micro and sub-micro scale is considered a key technology for miniaturizing mechanical parts and complete machines. Micro manufacturing techniques find application in various industries such as electro-communications, semi-conductors, medicine, and ultra-precision machinery.

A suitable manufacturing technique for mass production of these micro scale components needs to be established. The current techniques used for machining these components are mainly the dry vacuum process and wet chemical etching. These techniques come under the non-conventional machining processes category.

However, they are unable to produce 3D components and components with high aspect ratio. Most of these techniques were developed for the electronics industry specifically silicon. Silicon does not find applications in fields other than the electronics industry because it is toxic. High exposure to silicon dust causes chronic respiratory problems. These techniques also suffer from limitations such as restricted materials choice, inability to produce complex profiles, and huge investment for facilities and equipment.

II. LITERATURE REVIEW

Aron J et al. (2012) Non-destructive process control metrology of high aspect ratio (HAR) holes and trenches has long been a known gap in metrology. Imaging the bottoms of at-node size contact holes in oxide with aspect ratios beyond 10:1 has not yet been demonstrated. Nevertheless, holes and trenches of 30:1, 40:1, or even 60:1 will soon enter production, with these etches being applied to various homogeneous and multi-layer stacks of Si and SiO₂. The need comes from Moore's Law and increasing functional density on microchips, on which true 3D memory devices will soon be manufactured. These can take many different forms, but a common building block will be these ultra-HAR etched

features. In that work, They show experimental results and simulations from the NIST JMONSEL program to assess the feasibility of measuring such features using both conventional low voltage scanning electron microscopy (SEM) and higher beam energies and low vacuum conditions to ameliorate charging. In their measurements, higher voltage SEM did not improve upon conventional critical dimension (CD)-SEM. Simulations suggest the reason is a failure to overcome a negative oxide potential. Although a signal can in principle be detected from the bottom of contact holes in typical imaging conditions in the CD-SEM, it is likely that it will be very small and possibly below the noise floor.

Azad mohammed et al. (2018) Definition of scanning electron microscopy (SEM) was presented in terms of the main component of the instrument and step-by- step the process of SEM system. Schematic drawings with SEM components pictures were provided for understanding the procedure of work in easy and true way. Also, types of SEM were presented and discussed. The capability of energy- dispersive spectrometer (EDS) was also presented; this included historical background of EDS and how it works in accordance with SEM.

B Bhattacharyya et al. (2003) Non-conventional machining is increasing in importance due to some of the specific advantages which can be exploited during micromachining operation. Electrochemical micromachining (EMM) appears to be a promising technique, since in many areas of application, it offers several special advantages that include higher machining rate, better precision and control, and a wider range of materials that can be machined. A better understanding of high rate anodic dissolution is urgently required for EMM to become a widely employed manufacturing process in the micro-manufacturing domain. An attempt has been made to develop an EMM experimental set-up for carrying out in depth research for achieving a satisfactory control of the EMM process parameters to meet the micromachining requirements. Keeping in view these requirements, sets of experiments have been carried out to investigate the influence of some of the predominant electrochemical process parameters such as machining voltage, electrolyte concentration, pulse on time and frequency of pulsed power supply on the material removal rate (MRR) and accuracy to fulfil the effective utilization of electrochemical machining system for micromachining. A machining voltage range of 6 to 10 V gives an appreciable amount of MRR at moderate accuracy. According to the present investigation, the most effective zone of pulse on time and electrolyte concentration can be considered as 10–15 ms and 15–20 g/l, respectively, which gives an appreciable amount of MRR as well as lesser overcut. From the SEM micrographs of the machined jobs, it may be observed that a lower value of electrolyte concentration with higher machining voltage and moderate value of pulse on time will

produce a more accurate shape with less overcut at moderate MRR. Micro-sparks occurring during micromachining operation causes uncontrolled material removal which results in improper shape and low accuracy.

Cagnon L et al. (2003) Application of ultrashort voltage pulses to a tiny tool electrode under suitable electrochemical conditions enables precise three- dimensional machining of stainless steel. In order to reach submicrometer precision and high processing speed, the formation of a passive layer on the work piece surface during the machining process has to be prevented by proper choice of the electrolyte. Mixtures of concentrated hydrofluoric and hydrochloric acid are well suited in this respect and allow the automated machining of complicated three- dimensional microelements. The dependence of the machining precision on pulse duration and pulse amplitude was investigated in detail.

Dahai Mi (2015) Holes with complex internal features are difficult to machine with traditional mechanical machining methods. In their paper, a novel electrochemical machining (ECM) method using a tool electrode with controlled conductive area ratio to shape the complex inner surface of the hole was presented. The machining process was modelled to investigate the electric potential and current density distribution on the electrodes' surface and in the electrolyte, and the evolution of the shape of inner surface of the hole. Simulation results showed that the proposed ECM method has the potential to create holes with various complex internal features. A prototype tool electrode with gradually decreased conductive area from its tip to the root was fabricated and used in the verification experiment.

Dale E et al (1996) The gaseous secondary electron detector (GSED) in the environmental scanning electron microscope (ESEM) permits collection of electron signals from deep inside blind holes in both conducting and insulating materials. The placement of the GSED as the final pressure-limiting aperture of the ESEM creates a situation of apparent illumination along the line of sight of the observer. In principle, any point struck by the primary beam can be imaged. Image quality depends on the depth of the hole. In brass, features at the bottom of a 1.5 mm diameter hole that was 8 mm deep were successfully imaged.

J. Bannard (1977) The end of 1974 the scientific literature contained over 1200 articles on electrochemical machining (ECM). Additionally approximately 100 papers appeared in 1975. Although a large number of those references appeared in what might be described as „non-learned“ journals, this still leaves the potential student with a difficult task if he wishes to review the state of the art.

Kozak Jet al. (2004) The results of theoretical and experimental investigations of the relationship between the

characteristic shape dimensions imported upon the anode-work piece surface by the micro-features of the cathode-tool electrode under given machining conditions are presented. That research included the study of electrochemical copying of slots, mini-holes, grooves and insulating groove features.

The limiting conditions of micro-ECM are considered from the point of view of copying and micro-shaping using non-profiled tool electrodes. For improving micro-machining capabilities of ECM processes, the application of ultra-short pulse current and ultra-small gap size is recommended. The results of investigation of pulse micro-ECM using non-profiled electrodes are also discussed in the paper.

Nazile Ural (2021) His study aims to emphasize the importance of scanning electron microscopy (SEM) in explaining the differences in the physical and mechanical behaviors of the improved clays before and after improvement. Generally, clays appear as problematic soils in the construction area.

The reasons for this can be low strength, high compressibility, high level of volumetric changes, and swelling potential. The behavior of clays may not always be interpreted according to their physical and mechanical properties. In such cases, analyses are carried out according to the microstructure of the clay. Among several microstructural analyzes, SEM is very important, because the soil microstructure formed by clay particles and additives can be observed. This work discusses the studies based on the microstructural properties of the improved clay with SEM analysis. As a result of the studies carried out, it has been seen that unexplained physical or mechanical behavior can be explained by the microstructural behaviors of clay particles and additives.

III. EXPERIMENTAL METHODOLOGY

Design of Ecmm Setup

Project design is an opportunity to align on ideas, processes, and deliverables. It's an early phase in the project lifecycle and often comes before a project plan or charter. This is because it focuses on the project overview rather than the specific details. The given electrochemical micromachining drawing dimensions are represented in millimetre (mm).

Wooden Structure

The wooden structure is used with the purpose of reducing the cost of manufacturing and then it is designed with the consideration of minimum and maximum range of tool movement into the work space. Figure shows the structure front view and top view.

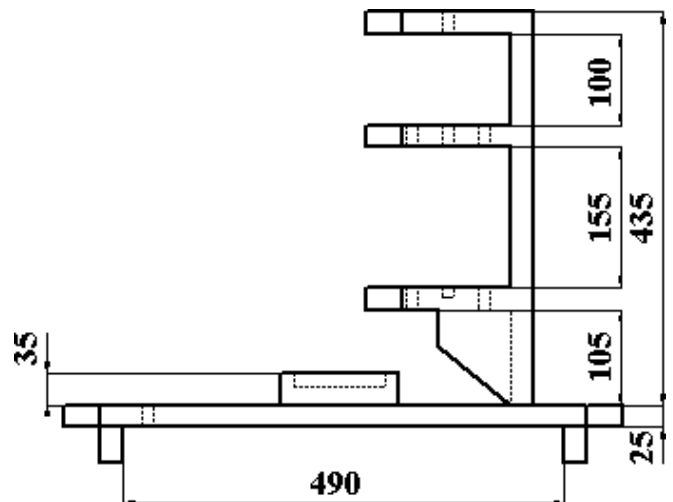


Figure 1. Structure front view

Guide Rod and Nut

The Guide rod is plays a major role on the tool feed during machining.

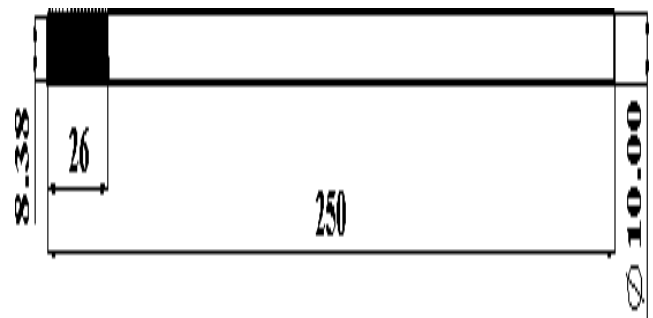


Figure 2. Guide rod

It guides the tool setup in vertical axis without allow the tool setup in any other axis. The nut is designed with respect to dimensions of the thread in guide rod and main rod by modifying the pitch. The figure shows the dimensions of the guide rod and the front view and top view of the nut.

Cad Model

Computer-aided design (CAD) is a technology that uses computers to create, modify, analyse, or optimize designs. It's a combination of hardware and software that allows designers to create and produce designs and technical drawings in 2D and 3D. The CAD software used for the modelling the ECMM Setup is SOLIDWORKS. It is a brand of dassault systèmes that develops and sells software for 3D CAD design, collaboration, analysis, and product data management. SOLIDWORKS has been an industry standard in design and engineering for over 25 years. The complete electrochemical micromachining model.

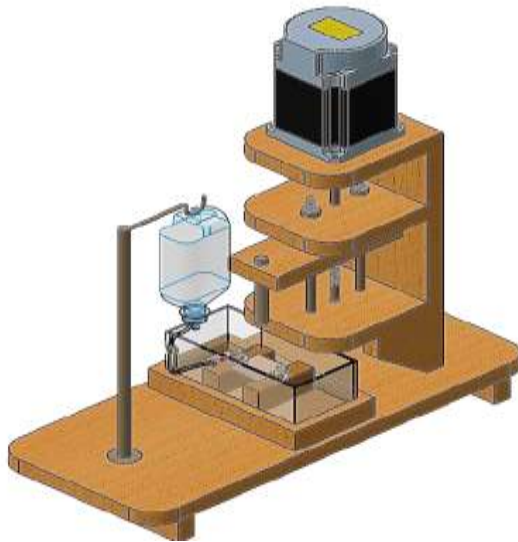


Figure 3. CAD Model.

- The convenience of not having to worry about plugging in a power source makes wireless options enticing.
- The device can be charged in a short amount of time.
- This configuration requires less room than a standard hardwired one.
- It's less bulky and more covert than a hardwired system.
- No live wires are exposed because there is no real connection.
- The risk of electrocution from utilizing corded equipment is eliminated.
- Newer WPT layouts are more effective than those before them.

IV. ANALYSIS RESULTS

In Electrochemical Micromachining (ECMM), where we the voltage is constant in 6V, the Electrolyte concentration is 30g to 50g per liter, and the Inter electrolyte gap is 0.2mm to 0.6mm ,Here the machining speed was decrease from 1.67 $\mu\text{m/s}$ to 1.45 $\mu\text{m/s}$. moreover overcut was increase from 189.1 μm to 210.3 μm .

where the voltage is constant in 9V, the Electrolyte concentration is 30g to 50g per liter, and the Inter electrolyte gap is 0.2mm to 0.6mm ,Here the machining speed was decrease from 2.08 $\mu\text{m/s}$ to 1.75 $\mu\text{m/s}$. moreover overcut was increase from 140.3 μm to 170.4 μm .

Efficacy based on the provided data, we would consider various factors such as machining speed, overcut, and the combination of parameters. In this case, let's assume that the overall highest efficacy corresponds to the combination of parameters that achieve the highest machining speed while keeping the overcut.

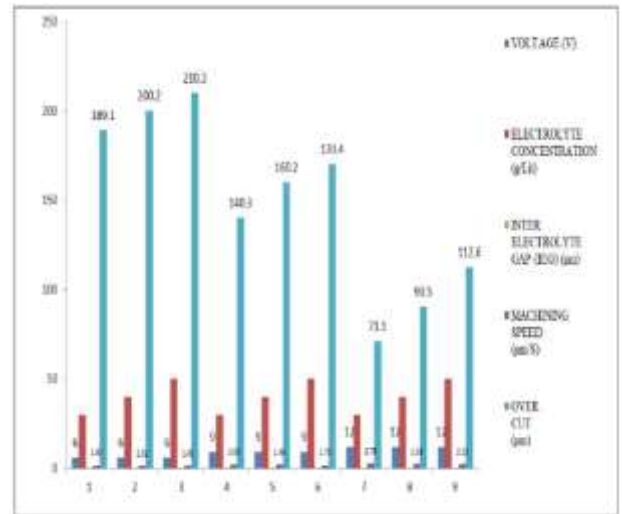


Figure 4 Graph - Effect of voltage, electrolyte concentration, Inter electrolyte gap on Machining speed and over cut

V. POLARIZATION CURVES

Polarization curves are commonly used in electro chemical corrosion studies to analyze the behavior of a material's corrosion potential and corrosion rate as a function of applied potential. However, "Corrosive" appears to be a misspelling or a specific term not widely recognized in the context of corrosion studies.

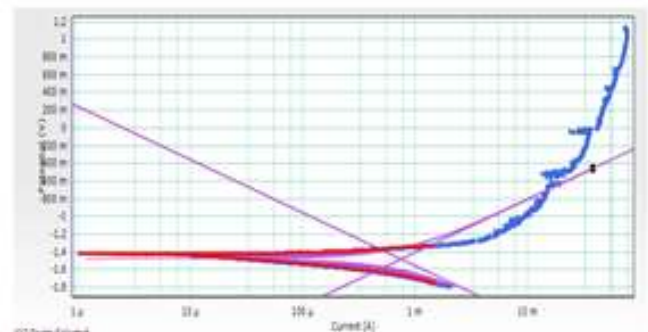


Figure 5. Current (A) vs Potential (V)

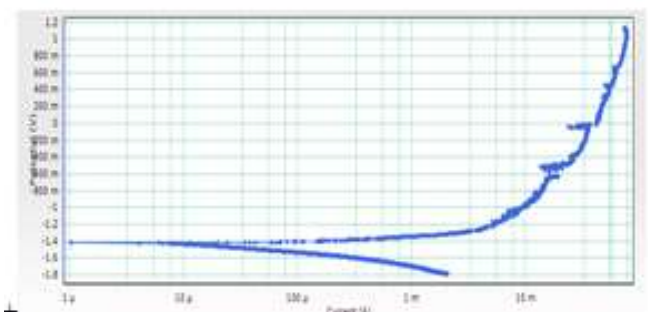


Figure 6. Current(A) vs Potential (V)

VI. CONCLUSION

The primary use of galvanized iron (GI) is in sheet metal roofing, building materials, and fencing, but its potential for micro level applications in science and nanotechnology is gaining attention. The design was done by computer aided design software. The process for electrochemical micro machining (ECMM) on galvanized iron (GI) sheet, we tested it out to see how well it works. We found that by adjusting factors like voltage, electrolyte concentration, and gap size between electrodes, we could control how fast the machine works and how precisely it cuts the GI sheet. Overall, we discovered that higher voltages and certain electrolyte concentrations led to faster and more precise machining, which is important for making small, accurate parts from GI sheet material.

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