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PARAMETRIC OPTIMIZATION OF ELECTROCHEMICAL MACHINING OF DIE STEEL- A REVIEW

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Abstract

Modernization of electro chemical machining is going on day by day and it plays very vital role for machining hard-to-machine materials that can't be performed by conventional machining process. The die steel is high carbon alloy steel with high hardness. The hardness value of die steel makes the difficult for conventional machining. Thus, conventional machining of die steel alloy is not economical. Die steel is used in cold Dies & tooling application that is required for the achievement of high degree of accuracy in hardening & tempering, such as dies drawing, forming cold rolls, powder metal tooling and blanking and trimming dies, blanking dies for paper and plastics, shear blades , cold die punches , Ejector pins etc. In this paper work related to the optimization of electrochemical machining parameters of various researchers using optimization methods like Response surface methodology (RSM), analysis of variance (ANOVA), grey relational analysis, taguchi based approach etc have been reviewed and categorised under three categories i.e. optimization on electrochemical machinig, optimization on different materials and optimization on various techniqes. Process parameters namely applied voltage, applied current, electrolyte concentration, work piece, electrical conductivity, types of electrolyte, etc are optimized. After applying optimization method simultanious effect of machinig parameters on metal removal rate (MRR) and surface roughness (SR) are observed. It is found that electrolyte concentration has the maximum influence on metal removal rate and surface roughness characteristics followed by current and voltage. The MRR increased with increase in voltage as well as tool feed rate.

Keywords: Electro Chemical Machining, material removal rate, RSM method

Introduction

The ECM is capable of machining geometrically complex shapes or hard material components, that are precise and difficult to machine such as heat treated tool steels, super alloys, ceramics, composites, carbides, heat resistant steel etc. being widely used in die and mold making industries, aerospace, aeronautics and nuclear industries. Electrochemical machining developed in late 1950's has been accepted worldwide as a standard process in manufacturing. Electrochemical machining is interesting because resulting in higher finish with stressed crack free surface and independent on the hardness of material .

Optimisation Method

The experiment designs mentioned in Two Level Factorial Experiments and Highly Fractional Factorial Designs help the experimenter identify factors that affect the response. Once the important factors have been identified, the next step is to determine the settings for these factors that result in the optimum value of the response. The optimum value of the response may either be a maximum value or a minimum value, depending upon the product or process in question. For example, if the response in an experiment is the yield from a chemical process, then the objective

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might be to find the settings of the factors affecting the yield so that the yield is maximized. On the other hand, if the response in an experiment is the number of defects, then the goal would be to find the factor settings that minimize the number of defects. Methodologies that help the experimenter reach the goal of optimum response are referred to as response surface methods.

LITERATURE REVIEW

Kozak et al. Did work on Mathematical models for computer simulation of electrochemicalmachining processes. Electrochemical machining (ECM) is an important manufacture technology in machining difficult-to-cut materials and to shape complicated contours and profiles with high material removal rate without tool wear and without inducing residual stress. This paper presents the physical and mathematical models on the basis of which of the simulation process module in the computer-aided engineering system for ECM (CAE-ECM) has been developed.

Rajurkar et al. He did new developments in electrochemical machining. He said that electrochemical machining (ECM) has traditionally been used in highly specialized fields such as those of the aerospace and defense industries. It is now increasingly being applied in other industries where parts with difficult-to-cut materials and complex geometry are required. In this paper the latest advances are discussed, and the principal issues in ECM development and related research are raised. Developments in tool design, pulse current, micro-shaping, finishing, numerically controlled, environmental concerns, hybrid processes, and recent industrial applications, are covered.

Ruszaj et al. Did work on some aspects of the electrochemical machining process supported by electrode ultrasonic vibrations optimization. Primary investigations of the electrochemical micromachining process supported by electrode ultrasonic vibrations have been carried out by them. As a result the basic characteristic of this process and optimal process parameters for which surface roughness is minimal have been found. It has been proved that electrode ultrasonic vibrations help to decrease the surface roughness parameter *R*a in comparison to the classical electrochemical process. They also presented the analysis of phenomena occurring in the machined area and indications for further investigations.

Kim et al. They had performed micro electrochemical machining of 3D micro structure using dilute sulfuric acid. Micro electrochemical machining (ECM) using ultra short pulses with tens of nanosecond duration is presented. 0.1 M sulfuric acid was used as electrolyte and 3D micro structures were machined on stainless steel. To prevent taper, a disk-type electrode was introduced. To improve productivity, multiple electrodes were applied and multiple structures were machined simultaneously. Since the wear of tool electrode is negligible in ECM, micro wire can be used as tool electrode. Using a platinum wire electrode with 10 pm diameter, various 3D features were machined on stainless steel plate. The change of the machining gap was investigated according to pulse condition and machining time. The disk-type electrodes were applied to micro electrochemical milling. He said that since ECM does not suffer from tool wear, a micro wire can be applied for micro cutting like wire EDM. By wire ECM, micro grooves were machined.

Jo et al. He worked on electrochemical machining for complex internal micro features. In this paper, the application of micro electrochemical machining (ECM) for the micromachining of internal features is investigated. By controlling pulse conditions and machining time, micro features are machined on the side wall of a micro hole. These methods can easily machine a

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micro hole with larger internal diameters than the entrance diameter, which is very difficult to do by the conventional processes. A micro disk-shaped electrode with an insulating layer on its surface is also introduced to machine microgrooves inside the hole. The purpose of this study was to confirm the various possibilities of making complex internal structures in a micro hole by micro ECM. In this paper parameters taken to control the machining gap by increasing or decreasing pulse on-time, pulse voltage, or machining time. By using this method, it is possible to control the diameter of the hole during drilling and to make the hole's entrance size smaller than the inside. In order to prevent over-dissolution during the machining, the use of insulation on the electrode was suggested. To make an internal groove in the micro hole, a disk electrode was used. He said that a groove array canal so be fabricated, because there is no tool wear during ECM.

Xu et al. Studied the surface roughness in wire electrochemical micro machining. Wire electrochemical micro machining (WEMM) has many advantages in machining metal structures. Even though surface roughness is one of the important indicators for measuring processing quality, it has not been paid enough attention to when using WEMM. In this paper he used cathode travelling and anode vibration to enhance mass transport and to improve the machining surface roughness, because electrolytic products accumulate easily in the machining gap, which causes a rough surface. Optimal conditions were taken a speed of 400 ms^{-1} with an amplitude of 100µm for cathode travelling and a frequency of 5Hz with an amplitude of 100µm for anode vibration. As a result surfaces with Ra= 0.058 µm and Rmax= 0.670 µm were obtained. Pulse conditions determined the amount of electrolytic products and also the influence of mass transport. A low voltage and short pulse duration reduced the electrolytic product, and a long period allowed more time for mass transport, which both led to allow dissolution rate. However, too low a dissolution rate caused short circuiting in the WEMM process, which resulted in high surface roughnesses. Therefore, an optimal pulse condition of 6V, 40 ns duration and 6 µs period was obtained.

Shankar et al. Did work on QFD-based expert system for non-traditional machining processes selection. Selection of an optimal non-traditional machining (NTM) process for generating a desired feature on a given material requires the consideration of several factors among which the type of the work piece material and shape to be machined are the most significant ones. This paper presents a quality function deployment (QFD) based methodology to ease out the optimal NTM process selection procedure. It includes the design of a QFD-based expert system that can automate the decision making process with the help of graphical user interfaces and visual aids. The developed expert system employs the use of a house of quality (HOQ) matrix for comparison of the relevant product and process characteristics. The weights obtained for various process characteristics are utilized to estimate an overall score for each of the NTM processes. Finally, if some of the NTM processes satisfy certain critical criteria, they are again compared with each other on the basis of their overall scores and the process having the maximum score is selected as the optimal choice. It was noted that the approach not only helps in selecting the optimal NTM process but also provides comparative study between the alternative NTM process. The comparative study between the alternative NTM processes helps in developing and deploying the available technologies by focusing onto the process characteristics that are not present in the considered processes in terms of their capabilities to generate a specific shape feature on a given material.

Kalaimathi et al. Experimentally investigated on the electrochemical machining characteristics of Monel 400 alloys and optimization of process parameters. Monel 400 alloys

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are used in various fields such as aerospace industries, marine industries, etc. It was very difficult to machine Monel 400 alloys using conventional machine tools. The present work was carried out to investigate the influence of ECM process parameters, such as applied voltage (V), inter electrode gap (IEG) and electrolyte concentration (EC), on material removal rate (MRR) and surface roughness (Ra) during machining Monel 400 alloys. An aqueous sodium chloride (NaCl) was used as a basic electrolyte in the electrochemical machining of Monel 400 alloys. The effects of process parameters as well as their interactions were investigated and the process parameters were optimized through the desirability function of the response surface methodology. Mathematical models had also been developed based on the RSM approach for correlating the MRR and R_a with process parameters. The adequacy of the developed mathematical model had been tested through the analysis of variance (ANOVA). It was concluded from the developed mathematical model that the optimal machining parametric combination, i.e., IEG=0.2 mm,V=18 V and EC=130 grams per litre was found out to achieve the maximum material removal rate, i.e., 0.5546 grams per minute and minimum surface roughness as 1.5216 µm.

Mohanty et al. Studied material removal rate, surface roughness & microstructure in electrochemical machining of inconel 825. Electrochemical machining (ECM) is one of the widely used non-traditional machining processes especially used for producing intricate or complex geometry on difficult-to-machine materials. Owing to this capability of machining any electrically conductive materials irrespective of its hardness, this process can be utilized to machine Ni-based super alloys which are termed as difficult-to-cut materials due its properties such as low thermal conductivity, high strain hardening tendency and high mechanical properties which although makes it very useful for high temperature applications but on the other hand it possess a significant challenge to machine by any conventional machine. The present study investigates the effect of various process parameters on performance characteristics such as material removal rate (MRR) and surface roughness (SR) when ECM of Inconel 825 by copper tool in an aqueous solution NaCl solution. An attempt has also been made to study the microstructure of machined surface at different conditions and to correlate it with multiple performance characteristics. This paper presented the use of Taguchi methodology in optimizing the ECM process parameters. He concluded that the MRR increased with increase in voltage as well as tool feed rate. The SR initially increased with concentration but it decreased at higher concentration. The percentage contributions of most significant process parameters i.e. voltage towards the MRR and SR was found to be 36.71 and 25.05respectively. Optimal condition for MRR was found to be at 50 g/lit concentration of electrolyte, 15v voltage and 0.3 mm/min feed rate .The optimal condition for SR was found to be at 30 g/lit concentration of electrolyte , 15v voltage and 0.2 mm/min feed rate.

Zhu et al. Did work on improvement of electrochemical accuracy by using dual pole tool. He said that electrochemical machining (ECM) is one of the best alternative for producing complex shapes in advanced materials used in aircraft and aerospace industries. However, the reduction of the stray material removal continues to be a major challenge for industries in addressing accuracy improvement. This study presents a method of improving machining accuracy in ECM by using a dual pole tool with a metallic bush outside the insulated coating of a cathode tool. The bush was connected with anode so the electric field at the side gap area was substantially weakened. The modelling and simulation indicated that the dual pole tool brings down the current density at the side gap area of the machined hole and hence reduces the stray material removal there. It had been experimentally observed that the machining accuracy and the process stability were significantly improved.

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Berger et al. Studied electrochemical machining characteristics and resulting surface quality of the nickel-base single-crystalline material LEK94. Nickel-base single-crystalline materials such as LEK94 possess excellent thermo-mechanical properties at high temperatures combined with low density compared to similar single crystalline materials used in aero engines. Since the components of aero engines have to fulfil demanding safety standards, the machining of the material used for these components must result in a high geometrical accuracy in addition to a high surface quality. These requirements were achieved by electrochemical and precise electrochemical machining (ECM/PECM). In order to identify proper machining parameters for PECM the electrochemical characteristics dependent on the microstructure and the chemical homogeneity of LEK94 were investigated in this contribution. It depends on the size of the machining-gap, the applied voltage and the electrical conductivity of the electrolyte used. It was concluded that low current densities yield inhomogeneous electrochemical dissolution of different micro structural areas of the material and lead to rough surfaces. He also said that high surface qualities can be achieved by employing homogenous electrochemical dissolution, which can be undertaken by high current densities.

Klocke et al. Technological and economical comparison of roughing strategies had been done via Milling, EDM and ECM for Titanium- and Nickel-based Blisks. He said that due to particular mechanical and thermal properties titanium- and nickel-based alloys such as Ti-6Al-4V or Inconel 718 are in common use as blisk materials. Besides conventional milling in this paper two alternative technologies for roughing operations in blisk manufacture – Electro Discharge Machining (EDM) and Electrochemical Machining (ECM) – were presented. Therefore material removal rates in Sinking-EDM (SEDM) and ECM were determined for the above mentioned materials and class of geometries. It was demonstrated that for distinct geometries, materials and batch sizes unconventional manufacturing technologies were economic alternatives to existing milling strategies. He concluded that depending on the specific geometry in case of Ti-6Al- 4V either milling or ECM is the most cost-effective technology and for Inconel 718 EDM could be a real alternative especially for smaller batch sizes.

Ningsong et al. Did work on Wire electrochemical machining with axial electrolyte flushing for titanium alloy. He stated that Titanium and its alloys have found very wide application in aerospace due to their excellent characteristics although their processing is still a challenge. Electrochemical machining is an important issue in the fabrication of titanium and titanium alloys. Wire electrochemical machining (WECM) is mainly used for workpiece cutting under the condition of different thickness plates. It has a great advantage over wire electro-discharge machining, which is the absence of heat-affected zone around the cutting area. Moreover, the wire electrode in WECM could be used repetitively because it is not worn out. In this paper, the axial electrolyte flushing was presented to WECM for removing electrolysis products and renewing electrolyte. The Taguchi experiment was conducted to optimize the machining parameters. The optimal machining parameters were taken 2.5% NaCl + 2.5% $NaNO_3$, 5 mm nozzle-workpiece distance, 87 m/s electrolyte flow rate, 18 V working voltage, and 1.8 mm/min wire feed rate. Experimental results were shown that WECM with axial electrolyte flushing is a promising issue in the fabrication of titanium alloy (TC1) and the machining productivity of wire electrochemical machining could be improved by multi-wire electrochemical machining.

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Sarkar et al. Worked on parametric analysis of electrochemical discharge machining of silicon nitride ceramics. The electrochemical discharge machining (ECDM) has a potential in the machining of silicon nitride ceramics. This paper describes the development of a second order, nonlinear mathematical model for establishing the relationship among machining parameters such as electrolyte concentration, applied voltage and inter-electrode gap, with the machining criteria namely material removal rate(MRR), radial overcut (ROC) and thickness of heat affected zone (HAZ) during an ECDM micro drilling operation on silicon nitride. The model was developed based on response surface methodology (RSM). From parametric analysis it was concluded that applied voltage has more significant effects on MRR, ROC and HAZ thickness during ECDM micro-drilling operation as compared to other machining parameters such as electrolyte concentration and inter electrode gap.

Das et al. Optimized surface roughness and MRR in electrochemical machining of EN31 tool steel using grey-taguchi approach. The workpiece material used was EN31 tool steel for maximum material removal rate (MRR) and minimum surface roughness. Experiments were conducted based on Taguchi’s L27 orthogonal array (OA). Analysis of variance (ANOVA) was performed to get the contribution of each parameter on the performance characteristics. The optimal combination was electrolyte concentration 10%, voltage 10 V, feed rate 0.25 mm/min and inter-electrode gap 0.2 mm for maximum MRR and minimum surface roughness. Surface and contour plots were generated to study the effect of input parameters on MRR and surface roughness. Thus, it was cocluded that grey-based Taguchi method optimizes the process parameters fairly well and ANOVA reveals that electrolyte concentration has the maximum influence on metal removal rate and surface roughness characteristics.

Schubert et al. Did work on electrochemical machining of cemented carbides. This work was focused on the electrochemical behavior of tungsten carbide cobalt in alkaline ammonia electrolyte under near-ECM conditions. Potential dynamic measurements were carried out in an electrolyte mixture of sodium nitrate and ammonia. It was shown that a homogenous dissolution of both phases, the hard phase tungsten carbide and the binder phase cobalt, is possible with this electrolyte mixture. Additionally, galvanostatic pulse experiments coupled with polarographic analysis of the waste electrolyte were carried out to investigate the current efficiency of the machining process. It was concluded that Current efficiencies between 70 and 100% can be achieved under the chosen conditions dependent on the current density.

Choi et al. Analysed the electrochemical behaviours of WC–Co alloy for micro ECM. Micro electrochemical machining (ECM) of tungsten carbide with cobalt binder (WC–Co) was studied using ultra short pulses. In ECM, the machining characteristics were investigated according to machining conditions such as electrolyte, workpiece potential, and applied voltage pulse. Using a mixture of sulphuric acid (H2SO4) and nitric acid(NaNO3), microstructures with a sharp edge and good surface quality were machined on tungsten carbide alloy. The potentials of workpiece electrode and tool electrode were determined by considering the machining rate, machining stability, and surface quality of products. With the negative potential of the workpiece electrode, oxide formation was successfully prevented and shape with good surface quality in the range from Ra 0.069 µm to 0.075 µm were obtained by electrochemical machining. Moreover, the performance of ECM, which includes machining gap, tapering, surface roughness, and machining time, without tool wear was compared with that of electrical discharge machining (EDM). The machining gap of ECM was in the range of 3–5 µm and the taper angle of ECM was below 1◦. The micro-

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electrochemical turning process, which is similar to turning (lathing) in conventional machining, was introduced to fabricate micro shafts. It was concluded that the holes made by ECM showed considerable improvement in machining performance in various parameters except machining time. Therefore, although the machining time of micro ECM is long, micro ECM has the advantage over micro EDM in case of precise machining such as the fabrication of micro mold with high accuracy and surface roughness.

Liu et al. Did work on electrochemical slurry jet micro-machining of tungsten carbide with a sodium chloride solution. Electrochemical slurry jet micro-machining (ESJM) is a new non-conventional process that couples abrasive slurry jet machining (ASJM) and electrochemical jet machining (ECJM) concurrently. A micro-jet of abrasive particles and electrolytic solution is made to impinge on the target while applying a DC potential between the jet nozzle and the workpiece. According to him ESJM can be used to remove material that is difficult to machine through a combination of erosion, corrosion and synergistic effects. This study focused on ESJM of tungsten carbide (WC) using a pH-neutral NaCl electrolyte rather than an alkaline solution which is more commonly used in the electrochemical processing of WC. For the studied process parameters, it was shown that the erosion due to ASJM alone was not able to erode the WC, and that the corrosion under ECJM was slow and produced unacceptably wide channels. The combined ESJM process however, was found to involve erosion of the developed oxide layer and subsequent exposure of un-corroded WC, leading to a much higher machining current density, corrosion rate, and machining localization than using ECJM alone. It was also found that the total abrasive kinetic energy, working voltage and solution concentration strongly affected the machining current density, material removal rate and aspect ratio (depth to width ratio). A comparison between ASJM, ECJM and ESJM revealed that ASJM was not effective in eroding WC with Al2O3 abrasives under the present conditions. While ECJM could corrode WC using a pH-neutral NaCl electrolyte, it resulted in a relatively poor machining resolution (i.e. a wider channel for a given depth), and a lower current density than ESJM. In summary, ESJM exhibited a great potential to micro-machine hard-to-cut materials such as WC, with high efficiency and low cost.

Oschatzchen et al. Did work on Microstructuring of carbide metals applying Jet Electrochemical Machining. He said that electrochemical machining (ECM) is a potential procedure for high precision micro manufacturing. Especially the machining of work pieces without any thermal or mechanical impact is a significant feature. Additionally, the electrochemical dissolution behaviour of the work piece material is only defined by its electrochemical attributes. Hence, mechanical characteristics such as the material's hardness and the ductility had no influence. This makes ECM an alternative process for mechanically hard to machine materials. In this study, a special procedure for machining micro geometries in carbide metal alloys was investigated, where a continuous electrolytic free jet (Jet Electrochemical Machining – Jet-ECM) was applied. The special characteristic of this technology is the restriction of the electric current to a confined area by the jet, which leads to a high localization of the removals. Even complex structures can be machined by the help of continuous direct current. Hence, higher dissolution rates compared to pulsed electrochemical processes can be achieved. In the experiments the machining of step holes and grooves in tungsten carbide alloys was performed. Therefore, point erosions without nozzle movement and linear erosions by single- and multi-axis motions of the tool were conducted. In addition, three-dimensional shaping of the investigated materials was presented by overlapping linear erosions.

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Bhattacharya et al. Investigated for controlled electrochemical machining through response surface methodology-based approach. This paper highlights features of the development of a comprehensive mathematical model for correlating the interactive and higher-order influences of various machining parameters on the dominant machining criteria, i.e. the metal removal rate and the overcut phenomena, through response surface methodology (RSM), utilising relevant experimental data as obtained through experimentation. He concluded that optimal combination of these parameters can be used in order to achieve maximisation of the metal removal rate and the minimum overcut effects for optimal accuracy of shape features.

Rao et al. Studid precision finishing of external cylindrical surfaces of EN8 steel by electro chemical honing (ECH) Process using OFAT technique. Electro Chemical Honing (ECH) is a hybrid machining process combining the material removal capability of ECM process with mechanical Honing (MH) operation. ECH is a well known process for offering excellent work surface quality on material of any hardness as long as it is electrically conductive. The paper describes the design and fabrication of an indigenously developed tooling setup for ECH of an external cylindrical components. Titanium alloys (TI 6AL 4V) and EN8 Steel were used as the work piece material for carrying out the experimentation to describe the material removal and surface roughness characters. The experimental conclusion was made on the basis of the results of experiments obtained by ECH process,12 minutes as finishing time , a mixtute of ¾ NaCl + ¼ NaNO3as electrolyte composition, a level of 10% of electrolyte concentration and a temp of 350C as electrolyte temperature were found optimum for precision super finishing of external cylindrical surfaces of EN8 Steel material. The results were shown that, all the four parameters are highly important to achieve the better surface finish and also for better amount of material removal.

Tiwari et al. Optimized the overcut in electrochemical machining for EN 19 tool steel using taguchi approach. Objective of the work is to achieve best optimal combination of various input parameter for radial over-cut (ROC) in electrochemical machining for EN 19 tool steel with copper electrode applying S/N ratio approach, analysis of variance (ANOVA) and taguchi technique. The input parameters taken were electrolyte concentration at 10%, voltage at 8 V, feed rate at 0.1 mm/min and inter-electrode gap at 0.2mm. It was concluded that voltage has the maximum influence on metal Over-cut fallowed by concentration and feed rate. The electrolyte concentration, voltage, feed rate, and inter electrode gap influenced the material removal rate by 12.10%, 35.99%, 3.90%, and 0.92% in the electrochemical machining of EN 19 tool steel, respectively.

Mishra et al. Did work on parametric optimization of ECH process for gear finishing by RSM and SAA. This paper presents the parametric optimization of electrochemical honing (ECH) of gears using response surface methodology (RSM) and simulated annealing algorithm (SAA) to predict the surface quality of gear teeth profile. On the basis of input parameters like 28.4 V as voltage, 65 rpm as rotating speed and 10% as electrolyte concentration at optimum setting of the parameters, he concluded that the process has shown an improvement of 91% in surface quality of gear teeth profile.

Yusup et al. Worked on evolutionary techniques in optimizing machining parameters: review and recent applications 2007-2011. In highly competitive manufacturing industries nowadays, the manufactures ultimate goals are to produce high quality product with less cost and time constraints. To achieve these goals, one of the considerations was by optimizing the machining process parameters such as the cutting speed, depth of cut, radial rake angle.

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alternative to conventional techniques, evolutionary optimization techniques were the new trend for optimization of the machining process parameters. This paper gave an overview and the comparison of the latest five year researches from 2007 to 2011 that used evolutionary optimization techniques to optimize machining process parameter of both traditional and modern machining. Five techniques were considered, namely genetic algorithm (GA), simulated annealing (SA), particle swarm optimization (PSO), ant colony optimization (ACO) and artificial bee colony (ABC) algorithm. It was found that GA was widely applied by researchers to optimize the machining process parameters.

Sonani et al. Reviewed tool wear estimation using response surface methodology. Tool wear is the progressive loss of material from the surface of tool in the form of very small metallic particles. From decade tool wear rate mostly used as to predict the tool lift. This paper discussed the development of first & second order mathematical model to predict the tool wear rate and the validation of the result by experiment using Response surface methodology. It was concluded that response surface method is best as compare to other method because it is easiest and time saving and cost saving technique.

Bahre et al. Investigated on pulse electrochemical machining characteristics of lamellar cast iron using a response surface methodology-based approach. In this contribution, the potential of Pulse Electrochemical Machining (PECM) for the machining of lamellar cast iron was investigated with regard to the machining performance during electrolysis with sodium nitrate as electrolyte and stainless steel as cathode. Therefore, the material removal characteristics of lamellar cast iron with PECM were determined by performing systematic design of experiments techniques applying an industrial PECM machine system (PEMCenter8000) to fulfil the effective utilization of the process and to minimize the number of trials. An analysis of the precision of the manufactured geometries and the possibility of generating defined surface qualities were contents of this study.

Bilgi et al. Studied the electrochemical deep hole drilling in super alloy for turbine blade application using copper electrode as tool. Experiments were performed by taking voltage, tool feed rate, bare tip length, electrolyte composition as input parameters to measure DAROC and MRR using HCl and NaCl as electrolyte. The empirical relationship between output parameters and input parameters were obtained by response surface methodology. Experiments were design using central composite rotatable design. DAROC varied significantly with voltage, bare tip length, and NaCl concentration. Tool feed rate had moderate effect, while HCl had small effect on DAROC. MRR varied with voltage, and bare tip length and the best hole was obtained at a voltage of 9V, tool feed rate of 0.9 mm/min, bare tip length of 0.9 mm, with an electrolyte containing 12.5 wt. % NaCl and 2.5 wt. % HCl.

Chakradhar et al. Did work on multi-objective optimization of electrochemical machining of EN31 steel by Grey Relational Analysis. The experiment were design by using L9 orthogonal array for three input parameters viz. electrolyte concentration, feed rate and voltage. Multi response parameters such as MRR, overcut, cylindrity error and surface roughness were optimized by using Grey Relational Analysis. The optimal parameter setting was electrolyte concentration at 15 %, feed at 0.32 mm/min and voltage at 20 V to maximize MRR and minimize cylindrity error, overcut and surface roughness.

Summary

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This paper shows the efficient use of optimisation methods like response surface methodology (RSM), analysis of variance (ANOVA), taguchi based approach, grey relational analysis etc in order to optimise ECM parameters like applied voltage, applied current, feed rate, electrolyte concentration etc. Based on the discussion made above it is very clear that electrolyte concentration has the maximum influence on metal removal rate and surface roughness characteristics followed by applied current and applied voltage. The metal removal rate (MRR) increased with increase in voltage as well as tool feed rate. Also, the surafce roughness (SR) initially increased with electrolyte concentration but it decreased at higher concentration of electrolyte. In case of tool wear estimation using response surface methodology it is concluded that response surface method is best as compare to other method because it is easiest and time saving and cost saving technique.

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