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Study of the process parameters involved in the Electrical discharge machining of tough materials - A review

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ABSTRACT

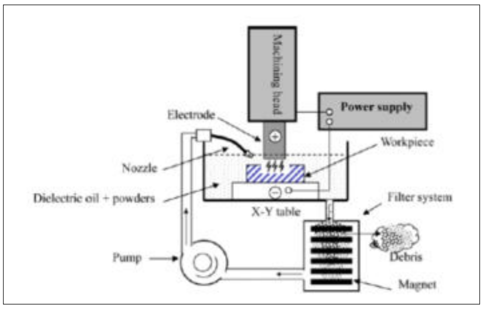
This work deals with the review of various papers related to optimization of Electrical discharge machining process. EDM is a manufacturing process by which tool cuts the required shape into the work piece within a dielectric fluid. Short duration discharges are generated in a liquid dielectric gap which separates the tool and work piece. The material is removed with an erosive effect of the electric discharges from tool and work piece. The electrical discharge in the EDM process is a highly complex phenomenon to which scientific knowledge is incomplete at both macroscopic and microscopic level. A comprehensive study is needed to improve the surface of electric discharge machined work piece. A mirror-like surface can be achieved by adding powder into dielectric via EDM process .The parameters considered are pulse on time, pulse off time, nozzle flushing, polarity, peak current and concentration.

Keywords : EDM, polarity, dielectric fluid, dielectric fluid

Introduction

As technological advances are taking place in the field of space research and nuclear industries in the world; very complicated and precise components having some special requirements are demanded by these industries. New developments are taking place in the manufacturing field to meet the new challenges. The unconventional methods of machining have several specific advantages over conventional methods of machining. The unconventional machining methods promise formidable tasks to be undertaken and set a new record in the manufacturing technology. These methods are not limited by hardness, toughness and brittleness of the material and can produce any intricate shape on any work material by suitable control over the various physical parameters of the process.

Figure 1 Experimental setup



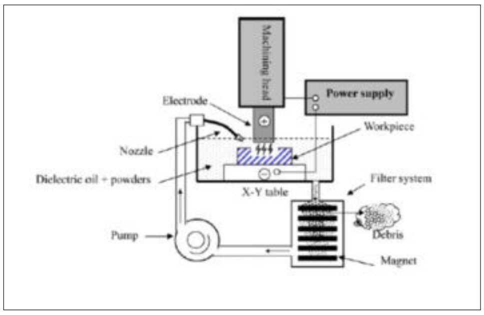
The rising production costs dictate that production operations be automated. The innovative materials such as super-alloys, composites, ceramics and many other advanced materials, which are difficult to or cannot be processed by traditional machining methods, require new manufacturing technologies. These engineering challenges facilitated the development of non-traditional manufacturing processes.

Literature review

Recast layer removal after Electrical discharge machining

This work uses EDM as the major process of machining materials. The workpiece for processing can consist of any materials as long as the materials have good electrical conductivity. Therefore, EDM applies widely for processing difficult materials since it performs with superior machining characteristics. Since the EDM process is a heat energy process, the processed part surface generates a heat-affected zone (HAZ) of Ni-based super alloy.

Figure 2 Diagram of self-designed filter system for the EDM



This zone includes the recast layer structure and surface morphology after removal processes. The recast structure has micro-cracks and discharge craters causing bad surface quality that are difficult to remove due to high cohesion and hardness characteristics compared to the base material. Such the recast structure greatly affects dye fatigue strength and shortens service life. The investigation explores surface crack formation by considering surface roughness, white layer thickness, and stress induced by the EDM process

Modelling and analysis of the rapidly re-solidified layer of SG cast iron in the EDM

EDM has been widely applied in modern metal industry for producing complex cavities in moulds and dies, which are difficult to manufacture by conventional machining. In the EDM process, the estimated discharge point temperature is thousands degrees (◦C) in order to rapidly melt machined material at this charge point. The layer thickness generally increases with the increase of the quantity and area fraction of graphite particle. But it reduces with the increase of diameter of graphite particle.

Performance evaluation of rapidly re-solidified layer

The performance of rapidly re-solidified layer is indicated by the layer thickness and the ridge density found in the upper surface of rapidly re-solidified layer. The experimental specimens, after machining, are washed and cleaned with a 3% dilute phosphoric acid solutions.

Machining of three-dimensional micro structures in silicon by EDM process

In electro-discharge machining (EDM), material removal starts when the generator applies a voltage between the work piece (the silicon wafer) and a tool electrode (a tungsten wire). This voltage is high enough to produce a spark between the two electrodes. The spark melts a small material volume on each of the electrodes. The dielectric fluid that fills the gap between the electrodes removes part of this material. The remaining part solidifies again on the surface of the electrodes. Through appropriate setting of the machining parameters, the material removal on the tool electrode (the electrode wear) can be kept at least an order of magnitude smaller than the material removal on the workpiece electrode. The net result of the spark is then a small crater on both workpiece and tool electrode. A second investigation concerns the machining of a plane with an arbitrary angle with respect to the top plane of a wafer.

Spacing roughness parameters study on the EDM of silicon carbide

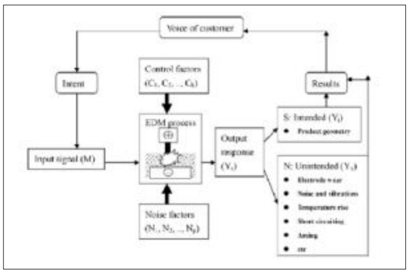
In line with current knowledge, the main inconvenience when applying the EDM technology to the field of ceramic materials is the electrical resistivity of these materials, where the limits are fixed between 100 and 300μcm. The selected ceramic material has been siliconised or reaction-bonded silicon carbide (SiSiC), whose field of applications (heat exchangers, wear parts, automotive water pump seals, radiant tubes for metal heat treating furnaces and furnace linings, among others) is in constant growth. In this way, a surface roughness study has been carried out on the influence of the following design factors: intensity (I), pulse time (ti), duty cycle (η), open-circuit voltage (U) and dielectric flushing pressure (P). The surface roughness study has been made using the statistical techniques of design of experiments (DOE) and multiple linear regression analysis [13-15]. In this case, a 5^{25-1} fractional factorial design with a resolution of V has been used to carry out the present study. Coefficient (4.3 - 4.6×10−6 K−1, 20 - 1000 ◦C), which provides it with a good resistance to thermal shock. Reaction bonded silicon carbide performs better under chemical corrosion than other ceramic materials, such as tungsten carbide or alumina (Al2O3). Therefore, it is frequently used as industrial furnaces lining.

The samples of silicon carbide used in the experiments were ground sheets of the following dimensions: 50mm×50mm×5 mm. Moreover, the electrodes used in this case were made of electrolytic copper (with a cross section of 12mm×8 mm) and they were subjected to a negative polarity as, according to the bibliography in the EDM field and the most stable and recommended way to EDM silicon carbide.

Modelling of surface finish in electro discharge machining based upon statistical multi-parameter analysis

In EDM, material is removed by means of repetitive spark discharges that cause local melting and/or evaporation of the workpiece material and the resulted surface is characterized by overlapping craters and features indicative of the intense thermal impact involved. EDM was performed on a HOSTEK SH-38GP (ZNC-P type) electro-discharge machine tool with working voltage (Ve) of 30V and open-circuit voltage of 100V. Experiments were conducted in typical dielectric oil (BP250) with electrolytic copper being used as the tool electrode (anode). The pulse current, Ie, and the pulse-on time, tp, considered to be the main operational parameters varied over a range from roughing to finishing, namely Ie: 5, 10, 20, 30 A; tp: 100, 300, 500 μs, thus resulting in 12 discrete pulse energies. Specimens of plain carbon steel Ck60 in the form of square plates of dimensions 70mm×70mm×10mm were used as work pieces (cathode).

Figure 3 Schematic of an EDM process as an engineering system



The multi-parameter surface texture analysis was performed using a Rank Taylor-Hobson Surtronic 3+ profilometer equipped with the Talyprof software. The main observations of the present work on the multi-parameter analysis of surface finish imparted to Ck60 steel plates by electro-discharge machining the following conclusions may be drawn that EDMed surfaces are revealed to be in view of topography "empty", "open", "steep" and "random" in shape whilst the parameters selected express quantitatively with satisfying agreement these features. The Observed characteristics become more profound, when intensifying the machining conditions.

Close correlation was revealed between certain surface texture parameters and EDM conditions. Obtained statistical regression models, either single or multiple, are characterized, in most of the cases, by very high correlation coefficients. The mutually independent parameters such as Ra and Wa, Rsk, Rku, β, D are considered to make-up a minimum set for surface texture description regarding both industrial quality control and research.

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