International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 5.22 (SJIF-2017), e-ISSN: 2455-2585
Volume 4, Issue 11, November-2018

A Review of Electrical Discharge Machining on Titanium based Alloy

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Abstract-Titanium belongs to the family of super alloys it is known as the metal of future because it possess potential to be used in aerospace, automobile industries, biomedical parts; surgical tool, due to excellent properties like high specific strength, low thermal expansion, good corrosion resistant at elevated temperature, also in subsea oil and gas operations, good wear etc. one of the major problem which is faced by the manufacturers in manufacturing Titanium parts is that it is very tough to use conventional machining process. Therefore it will be best to use thermo electric processes for machining super alloys like Ti64, Ti6246 etc. EDM are developed for micro-electrodes and micro-holes are actually used but most of them involve micro-EDM machining. In this work, the aim is to review the effect of machine parameters on Ti64 by varying parameters such as electric parameter and non-electric parameters on MRR, EWR, surface integrity, hardness, DVEE, surface topography, composition and problems related to flow of debris. The study reveals that MRR can be increased by adding 4.0 g/l fine suspended graphite particles (10 µm)in kerosene as dielectric fluid with 30% reduction in breakdown voltage at the cost of higher discharge frequency which in turns increases MRR which is greater in case of B4C particles in de-ionized water as die-electric fluid. SEM shows more micro cracks on machined surface due to crater mechanism these micro holes leads to failure of the component at high pressure and temperature conditions particularly in case of plane engine blades.

Keywords: - EDM, Ti-6Al-4V, Dielectrics, Micro holes, Copper electrode, MRR

INTRODUCTION

Electro Discharge Machining (EDM) is an electro-thermal non-traditional machining process, where electrical energy is used to generate electrical spark and material removal mainly occurs due to thermal energy of the spark.
EDM is mainly used to machine difficult-to-machine materials and high strength temperature resistant alloys. EDM can be used to machine difficult geometries in small batches or even on job-shop basis. Work material to be machined by EDM has to be electrically conductive.

Principle of electrical discharge machining
In die sinking EDM the material is removed from the work piece the repetitive sparks between the electrode and work piece. The tool is positively charged and the work piece is negatively charged. When electrode comes in contact with dielectric and work piece the spark is produced which helps in removal of material. The Die sinking EDM machine as shown in figure1.

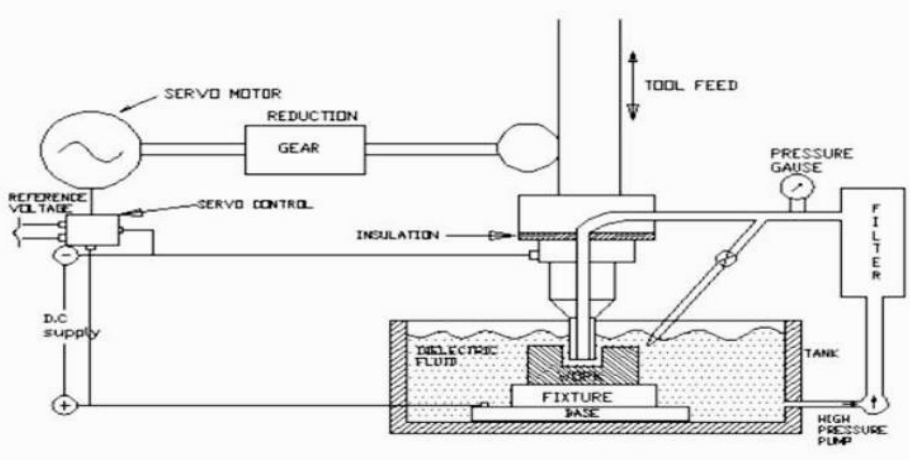

Figure 1: Die Sinking Electrical Discharge Machining

Types of electrical discharge machining

Electrical Discharge Machining can be classified into two types

1. Die-sinking Electrical Discharge Machining
2. Wire-cut Electrical Discharge Machining

Die-sinking electrical discharge machining

Die-Sinking EDM also known as vertical EDM , sinker EDM and plunger EDM. In Die sinking EDM the electrode which is positively charges i.e. Anode and too which is negatively charged i.e. cathode submerged in a die electric fluid (Kerosene or other dielectric fluids). The electrode and work piece are connected to suitable power supply. An electrical spark is created between electrode and work piece when power supply is ON. As electrode approaches work piece , the dielectric breakdown takes place in dielectric fluid starting through the power supply. Due to this process a plasma channel starts forming and spark jumps from the electrode to the work piece. The material removal rate or surface roughness depends upon the current , pulse on time and pulse off time. More the current , more the material removal rate but lesser the surface roughness .To get better surface finish low ampere current can be used in die sinking EDM.

CURRENT STATUS OF RESEARCH

Luo**[1]** investigated the dependence of interspace transitivity upon the gap debris in precision electric discharge machining, process stability. Experiments were conducted with machine parameters discharge duration: 0.2 μs, discharge current: 0.8 A, open current voltage: 60 V, electrode polarity: -ve, electrode down-time: 7 s, planetary motion speed: 6 mm/s. it has been found that discharge transitivity in gap space relies on the presence of a sedimentary debris layer on the work's surface with very low surface roughness (Ra<3 μm). For process stability gap size should be increased to evacuate more debris but helpful only in rough and median EDM not in precession EDM. Chen et al **[2]** studied the behavior of kerosene and deionized water as the dielectrics on Ti64 alloy. It was revealed that in application where temperature & Pressure is high kerosene as dielectric is best then distilled water. when kerosene is used as dielectric a thick layer of TiC is formed on the base metal which is good as it has less cracking problem at elevated temperature and pressure , whereas in case of distilled water there is an formation of thin layer of Tio with high chance of cracking. Jeswani **[3]** reveals that the addition of 4 g of fine graphite powder (10 μm) in kerosene increases MRR by 70% and TWR by 20%. The wear ratio is reduced by 30%.This effect may be due to reduction in breakdown voltage of kerosene dielectric due to the addition of the graphite powder results in a higher discharge frequency which in turn increases the MRR. Rahman et al **[4]** investigated the effect of the peak current and pulse duration on the performance of the EDM. It was concluded that the MRR increases linearly with the increase in current and also the surface roughness also increase with the increase in current. TWR increases with increase in peak current and it decreases with increase in pulse on time. Yan et al **[5]** studied the behavior of Urea solution and water as dielectrics on Titanium alloy. By using urea solution and increasing the peak current MRR increases and TWR decreases and also get smoother surface finish. When conventional water was used as dielectric MRR increases but TWR also increases. Kibria et al **[6]**comparative study have been done on different dielectrics viz. kerosene, deionized water with and without suspended particles of B4C and their effect on output parameters with respect to input process parameters such as peak voltage, current, impulse, polarity etc. This study was revealed that MRR and TWR were lesser using kerosene than deionized water with a micro thick white layer. But when we employed deionized water with suspended particles of Boron carbide TWR decreases and MRR increases in case of Ti-64 alloy. Pollution free property of deionized water makes it was of best choice dielectric. Pradhan et al **[7]** studied the effect on MRR TWR by changing the polarity .For first 10 min machining is done on normal polarity i.e. work piece as anode and tool as cathode and for next 5 sec polarity is changed i.e. work piece as cathode and tool as anode. By changing the polarity carbon deposition and debris become less and become easy to machine deep hole. Gill et al **[8]** done a comparative study of Deep cryogenic treatment tool and without Deep cryogenic tool. The results reveals that MRR increases and TWR decreases in case of EDD of DCT in Ti6246 alloy work piece by using Sic powder in kerosene dielectrics and also thickness of recast layer decreases. Dewangan **[9]** studied thoroughly and reached at some points after doing some investigation and found that the effect of machining parameters setting like pulse on time ,discharge current and diameter of tool of AISI P20 tool steel material using U-shaped copper electrode with interior flushing technique. Moreover the signal-to-noise ratios linked with the values which were observed during experiments and this ratio was determined by that factor which is most affected by the responses of MRR, OC and TWR.

Kiyak & Cakir **[10]** found that current and pulse on time has greater effect on work piece and electrode in term of surface roughness. If we increase these values (current and pulse on time) then the surface roughness of work piece and electrode was also increases. A better surface finish can be produced with the usage of lower value of current and pulse time and higher value of pulse off time. Lonardo and Bruzzone **[11].** studied the effect of electrode material size on Die sinking EDM. It was concluded that larger the frontal area of electrode larger the erosion takes place so, higher the MRR. Electrode material size also increases the EWR. Hadad et al **[12]** explore the impact of beginning apparatus surface on MRR, work piece surface roughness, TWR. It was well expressed that because of the peaks and valleys leads surface roughness of the work piece diminishes expanded TWR with lessened MRR at the cost of high voltage. Tomadi et al **[13]** studied and analysed that the effect of machine settings while working with material like tungsten carbide on the outputs like as TWR, MRR and surface finish. A confirmation test was performed to find out the error between the values that were predicted and the data which was collected through experiments and related to machining characteristics. This study revealed that while working with tool made by material copper tungsten work piece results in better surface finish. For full optimization they were using full factorial DOE and further they found that working with tungsten carbide with greater value of pulse off time the tool wear was minimum and as the values of parameters like current , voltage and pulse on time etc. increases the tool wear also increases. Singh et al**[14]** investigated that the overcut mainly influenced by the input process parameters like current, pulse on time, voltage applied and work piece, but this happens up to only certain limit. As current increases the overcut also increases and it also influence by the gap voltage. Simao et al. [**15**] developed work on different work pieces on different alloying surfaces and machining is done over electric discharge machining (EDM). In experiments the tools which are made with the help of powder metallurgy are used and the use of powders is eliminated in dielectric liquid. Based on the results of the experiments the tungsten carbide which is used for making of primary sintered electrodes will results in the development of a uniform and modified surface layer with some micro cracks and an average thickness of upto 30 micron meter. Bhattacharyya et al. [**16**] investigated on EDM with the help of producing a mathematical model which is based on RSM which is used for comparing the interactive and higher order effect with parameters like peak current and pulse on time on machining and the surface integrity of M2 Die steel machined through examination of EDM parameters on surface roughness, white layer thickness and surface crack density. Surface integrity is minimized with the help of developed model with optimal combination. Kumar et al. **[17]** studied and found that if machine setting is done at a very high value (peak) of current then it increases MRR, overcut , TWR and Ra in EDM of E31 tool steel when heat treated with different tool materials like brass, copper, aluminum and copper tungsten. With working these materials out of all materials copper and aluminum electrode gives higher MRR, working with copper and aluminum tungsten overcut in diameter is minimum. Abbas et al. **[18]** done his research on the previous trends of EDM like ultrasonic vibration assisted EDM , dry EDM , powder mixed EDM , water based EDM and various modelling techniques of EDM to precise and accurately EDM performance . After doing all research work they found that dry EDM is cost-effective , ultrasonic vibration assisted EDM is best suited for micro machining , safe and conductive working environment is provided when working with water based EDM , and for increasing surface quality work with powder mixed EDM and powder mixed EDM also increases MRR.

CONCLUSIONS

Following conclusions were drawn from literature survey.

- Among all the parameters during literature review of EDM , discharge current is the most significant and influencing factor for better results of MRR and followed by pulse on time and voltage on the given output.
- Up to some extent with respect to current MRR increases linearly and increases and decreases with pulse ontime later on.
- Thickness of recast layer is less when deionized water is used instead of kerosene..
- MRR increases when urea solution is used as dielectric also improves EWR.
- In case of cryogenic tool with Al + SiC particles in kerosene is used as dielectric which results in the improvement MRR, TWR and surface roughness.

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