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Analysis of MRR and Surface Roughness in Machining Ti-6Al-4V ELI Titanium Alloy Using EDM Process

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Abstract

Titanium alloy is widely used in various industries like aerospace and automobile industries because it has good strength to weight ratio. Titanium alloy is also use in petrochemical, architectural and various medical equipment industries. Machining of titanium is very difficult because of its poor thermal conductivity, high heat stress, high pressure loads, varying chip thickness and residual stress. In present work, Ti-6Al-4V ELI (Grade 23) was machined with EDM machining process taking pulse on time, voltage and current as the process parameters. Surface finish and Material removal rate of each job was calculated. Surface morphology was done on the machined surface to check the behavior of the work piece. Multi response Grey Relation Analysis (GRA) technique was used to optimize the process parameters and main effects plot was drawn to observe the impact of parameters over MRR and surface roughness. It is observed that MRR and surface roughness were directly proportional to discharge current. The optimized values associated with machining are as follows: 18A discharge current, 100 µs pulse on time and 40 V.

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Keywords: Electro discharge machining; Titanium alloy; Surface roughness; Material removal rate; Grey relation analysis

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1. Introduction

Titanium metal is the 9th super abundant element on the earth. Ti-6Al-4V ELI (Grade 23) has extra low interstitial form of Titanium grade 5 (Ti-6Al-4V) alloys which makes it tougher. Ti-6Al-4V ELI alloys are popularly used in marine engineering, medical and chemical industries because of its excellent corrosion resistance, high specific strength and cryogenic properties. It has low thermal conductivity which imparts higher amount of heat generation during cutting and makes it in poor machiniblity category. Difficulties in machining of titanium metal occurs mainly due to high cutting temperature, low modulus of elasticity and chemical reaction between tool- work piece interface [1]. Among non-conventional machining process electro discharge machining is a vital process, where a work piece is deep in a dielectric liquid. The tool is the cathode and the work piece acts as anode. Material removal takes place from the work piece by melting and evaporation due to the formation of spark between tool and the work piece [2, 3]. The experimental result showed pulse off time along pulse on time were most significant process parameters which effected the quality of surface finish and MRR [4].Experiment was done to discover the consequence of pulse time, current and servo voltage on electrode wear and machining time while using EDM process for machining of narrow slots in low machining materials. It was experimentally observed that pulse time and discharge current were the most affecting parameters which affected the electrode wear and machining time [5]. The current intensity was the most relevant term for variations in MRR. It was increased with current and pulse on time [6-7]. Surface finish and surface micro structure was found better using Cu-Sic electrode [8]. MRR greatly increases when current intensity increases due to rise in temperature of the material. Electrode wears decreases with increase in pulse time. Ra value is largest at high pulse time and high current intensity [9]. Micro cracks produced on the machined surface increases with rise in pulse on time. The formation of micro cracks decreases with decrease in pulse off time [10]. Experiment was done on Ti6Al4V alloy by using electro discharge machining as a surface treatment process for bio medical use. EDM with relative high peak current produced greater surface toughness and generated a carbon enriched surface over the job [11]. Surface roughness in EDM operation rises with increment in pulse on time and peak current but decline with increase in the flow pressure of the dielectric fluid [12].

2. Materials and methods

Electro discharge machining (EDM) is a non-conventional mechanized process in which material removal is accomplished from the job by sequence of swiftly recurring current discharge among two electrodes in presence of dielectric liquid. Here the removal of material from the parent work piece is assisted by the heat generated by the spark. In this experiment electronically model- SMART ZNC EDM machine was used. EDM oil grade 4(odorless and colorless) is used as the cutting fluid. For good circulation, the oil has low viscosity. Titanium alloy Ti-6Al-4V ELI grade 23 was taken as the wok-piece material. Among the three types of alloys i.e. alpha-beta-phase, alpha-phase, beta-phase; the chosen alloy is an alpha-beta wrought alloy. Copper electrode is used as the cutting electrode. Copper is a malleable and ductile metal. It has elevated thermal and electrical conductivity. The machining set-up, test specimen and copper electrode are displayed in Fig. 1a, Fig. 1b, and Fig. 1c respectively. Two responses say material removal rate (MRR) and surface roughness have been considered for analysis of machining performance. Three roughness parameters average surface roughness (Ra), roughness height (Rz) and maximum height of profile (Rt) have been considered. The experimentation procedure has been followed the following steps: Initial weight of each work piece was measured by using digital weighing machine. Perfectly cleaned copper rod was attached to the vertical tool post. On the work piece holder the job was fixed. Then the vertical tool post was moved down and positioning of the work piece was done. Pump was switched on and the stored oil entered in the reservoir. The coolant pipe was aimed between the job and the electrode. Then the flushing pressure value was entered and then the sparking switch was turned on and the experiment was carried. After that the final weight of the work piece was measured and noted down. Same procedure was adopted for remaining experiments.