Available online at www.sciencedirect.com

ScienceDirect

Materials Today: Proceedings 4 (2017) 1434–1441

materialstoday: PROCEEDINGS

www.materialstoday.com/proceedings

5th International Conference of Materials Processing and Characterization (ICMPC 2016)

Parametric Optimization in Wire Electrical Discharge Machining of Titanium Alloy Using Response Surface Methodology

Siva Prasad Arikatla[a], K.Tamil Mannan[b], Arkanti Krishnaiah[c] *

[a]*Research Scholar,SOET, IGNOU, New Delhi, India & Senior Lecturer, DA Govt. Polytechnic, Ongole, Andhra Pradesh, 523001, India*
[b]*Associate Professor, Department of MechanicalEngineering, School of Engineering & Technology, IGNOU, New Delhi, 110028, India*
[c]*Professor& Head, Department of Mechanical Engineering, Osmania University College of Engineering, Hyderabad, Telangana, India.*

Abstract

Wire Electrical Discharge Machining (WEDM) is extensively used for machining of complex shapes in the field of die and mould making, medical, aerospace and automobile industries for machining of too hard materials. Improper selection of WEDM process parameters setting can affect the machining efficiency and surface roughness due to arcing phenomenon that lead by electrical discharge. Present study has been made to optimize the process parameters during machining of titanium (Ti-6Al-4V) alloy by WEDM using response surface methodology (RSM). Five input process parameters of WEDM namely Pulse on time, pulse off time, servo voltage, input power and wire tensionwere chosen as variables to study the process performance in terms of kerf width, material removal rate (MRR), surface roughness. The analysis of variance (ANOVA) was carried out to study the effect of process parameters on process performance and mathematical models havebeen developed for response parameters. Properties of the machined surface have been examined by the scanning electron microscope (SEM).The experimental results revealthat the kerf width increases as the pulse on time, input power, server voltage and wire tension increases and the MRR increases as the pulse on time and input powerincreases. It is observed that as the pulse on timeand input power increases, the surface roughness also increases. Further it is observed that as and when the wire tension and servo voltage increases the surface roughness decreases and it improves the quality of machined surface.

*Keywords:*Wire electrical discharge machining, material removal rate, Kerf width, Surface roughness, RSM, ANOVA, SEM

* Corresponding author. Tel.: 919985439177
*E-mail address:*sparikatla@rediffmail.com

1. Introduction

Titanium alloys are hard metals which contain a mixture of titanium and other chemical elements. Ti-6Al-4V grade titanium alloy is the most popular alloy and is used for a wide range of applications in aerospace, marine, power generation and offshore industries etc.,. Titanium alloys have very good mechanical properties such as high tensile strength, fatigue resistance, light in weight (highest strength-to-weight ratio), extraordinary corrosion resistance, toughness even at elevated temperatures and able to withstand high temperatures. However, the high cost of both raw materials and processing of material limit their use to military applications, aircraft, spacecraft, medical devices, connecting rods on expensive sports cars and some premium sports equipment and consumer electronics. Automobile manufacturers Porsche and Ferrari are also used titanium alloys in engine components due to its durable properties in these high stress engine environments. Although "commercially pure" titanium has acceptable mechanical properties and has been used for orthopedic and dental implants, for most applications titanium is alloyed with small amounts of aluminum and vanadium. This mixture has a solid solubility which varies dramatically with temperature, allowing it to undergo precipitation strengthening. This heat treatment process is carried out after the alloy has been worked into its final shape but before it is put to use, allowing much easier fabrication of a high-strength product. Yang, X, Liu, CR et al., studied the machining of titanium and its alloys (1), Kuriakose, Sh, Shanmugan MS et at., studied the characteristics of wire electro discharge machined Ti-6Al-4V surface (2) and Rahman.M.M et al., have done the modeling of machining parameters of Ti-6Al-4V for electric discharge machining using a neural network approach (3). Titanium and its alloys are attractive and important materials in modern industry due to their unique properties. Titanium is a very strong and light metal. This property causes that titanium has the highest strength-to-weight ratio in comparison the other metal that are studied to medical use. Titanium is also incredibly durable and long-lasting. When titanium cages, rods, plates and pins are inserted into the body, they can last for upwards of 20 years. Titanium non-ferromagnetic property is another benefit, which allows patients with titanium implants to be safely examined with MRIs and NMRIs (4, 5). Titanium and its alloys are used in many different industries such as biomedical applications, automobile, aerospace, chemical field, electronic, gas and food industry (6). In recent decades, titanium is applied widely in biomedical and medical field because it is absolutely a proper joint with bone and other body tissue, immune from corrosion, strong, flexible and compatible with bone growth. Titanium is used in different medical applications such as dental implants, hip and knee replacement surgeries, external prostheses and surgical instruments (4, 7). Elias C.N et al., studied the Bio Medical applications of Titanium and its alloy (8) and Kumar A et al., has done the investigations into machining characteristics commercially pure titanium using CNC electric discharge machining (9). On the other hand, there is some limitation for titanium use because of its initial high cost, availability, inherent properties and manufacturability (9). Machining titanium and its alloys by conventional machining methods has some difficulties such as high cutting temperature and high tool wear ratio. Thus, titanium and its alloys are difficult-to-machine through conventional machining process. Therefore, unconventional machining processes are introduced for machining titanium and its alloys (2, 6). Gu.L, Rajukar K.P et al., studied the electric discharge machining of Ti-6Al-4V with a bundled electrode.

Wire Electrical Discharge Machining (WEDM) technology has been widely used in tool and die-making industry, automotive, medical and practically any conductive materials. It is a non-traditional machining process which used the continuously circulating wire as electrode and cuts the work piece along a programmed path. Wire Electrical Discharge Machining known as wire-cut EDM, a thin single-strand metal wire is fed through the work piece submerged in a tank of dielectric fluid. WEDM is typically used to make punches, tools, and dies from hard metals that are difficult to machine with other methods. Wire EDM is commonly used when low residual stresses are desired, because it does not require high cutting forces for removal of material. If the energy per pulse is relatively low, little change in the mechanical properties of a material is expected due to these low residual stresses, although material that has not been stress-relieved can distort in the machining process. The work piece may undergo a significant thermal cycle, its severity depending on the technological parameters used. Such thermal cycles may cause formation of a recast layer on the part and residual tensile stresses on the work piece.