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A Study on WEDM Process and the Effect of Microstructure on Titanium and its Alloys

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Abstract- Many composite materials with superior mechanical properties including a high strength-weight ratio are titanium alloys. Titanium alloys. But, these alloys' machinability is weak. Some non-conventional processing techniques for machining these alloys have been found to be useful. Machinery to cut hard metals such as titanium for wire electro-discharge (WEDM) is a method used to create complex shapes. Machinery to cut hard metals such as titanium for wire electro-discharge (WEDM) is a method used to create complicated shapes. In this research work a clear and wider knowledge on WDEM and its process parameters along with the effect of material feed rate, surface topography and residual stress.

Index Terms- Titanium, WEDM, Material Removal Rate, Surface Roughness.

I. Introduction

Titanium is a metal that's highly resistant to corrosion, fatigue-proof and weight-to-weight at a high temperature. The high strength at low and moderate temperatures, lightweight, excellent resistance to corrosion and wear, strong fatigue properties, highly biocompatible etc. makes titanium and its alloys very appealing in modern industry. However, characteristics such as the resistance to oxygen, nitrogen, and other impurities greatly affect the characteristics of such alloys [1]. It's a very solid, light metal of titanium. This property makes titanium in contrast to the other metal studied for medical application to have the highest strength-in-weight ratio. Even titanium is incredibly robust and strong. It takes up to 20 years to penetrate the body of cages, rods, plate and sticks. The non-ferromagnetic properties of titanium are also advantageous to people with titanium implants that can be tested safely with MRIs or NMRIs. For various medical uses, titanium is used, such as braces, hip and knee repair, exterior prostheses, and surgical instruments [2]. At the other hand, it has some negative consequences on the use of titanium because of its original high cost, quality, inherent properties and processing. Titanium and its alloys are processed using traditional methods that have certain problems, such as high cutting temperatures and a high wear rate for instruments. So it's hard to process titanium and its alloys. New technologies are then added for the handling of titanium and its alloys. This paper discusses the broad variety of work from the EDM to the WEDM method. The WEDM reports examine the effects of the different factors that influence machining efficiency and productivity on titanium alloy and optimization of process parameters [3].

II. Wire EDM

In the automobile and nuclear aerospace industries, Wire-EDM is a new electrical-thermal metal removal process that is used both to machine unusual forms of various materials hard to manipulate and electrical conducive. Wire-EDM is a particular type of electric discharge machinery in which the electrode is a constantly moving (electrically conductive) filament. The material removal during the Wire-EDM process is mostly due to the effect that spark discharges in a Dielectric Medium between the wire device and the workpiece trigger [4]. The entire process is done in three steps: the first phase of electric discharge is turned on. Such electrical discharges then melt and vaporize working particles that are flushed and washed off in the di electric medium (empty) on the workpiece. The Wire-EDM system has many dielectric injection pressure working parameters, such as applied voltage, pulsing speed, pulse-on-time, pulse-off-time, wire feeding rate, etc. This affects the metrics of efficiency including material extraction rate and surface roughness. Wire machining (WEDM) is an innovative thermal technology that can easily handle sections of various hardness or complicated forms, with sharp edges that are very difficult to manipulate by main stream machining processes [5]. This realistic WEDM technology focuses on the traditional phenomenon of EDM sparking, the general non-contact removal technique. At the start of the process WEDM has established the best solution for the development of micro-sized parts with the highest measuring precision and quality of surface design from a simple tool and die making method [6]. It can be constructed of fairly normal materials, such as paint and aluminum products, copper and graphite, rare space aged alloys, including hot alloys, Inconel, titanium, carbide, lightweight poly-crystalline diamonds, electrically conductive irrespective of hardness. In comparison to melting wheels and cutters, the work piece doesn't suffer physical strain. The pressure required for small, thin and delicate pieces is low and avoids damage to or distortion of the workpiece. The working process of WEDM technology is represented in figure 1.

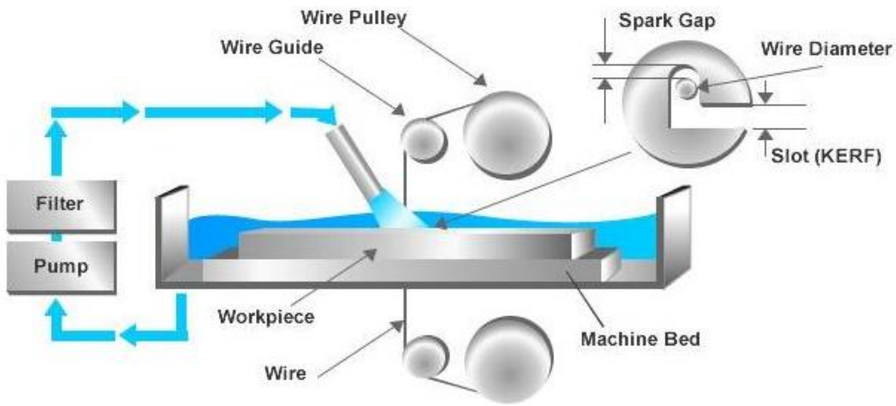

Figure 1. Wire EDM process [7]

III. PROCESS PARAMETERS OF WEDM:

Machining is one of the recent and earlier non-conventional electric-thermal methods used for producing short-lived electric sparks and high current densities between devices and electrodes. Electrical discharge machining is a beneficial electric power operation. The efficiency of part delivery depends on the removal rate and the ongoing search for high RRM and a low cutting time [8]. The research aims to optimize process parameters of Wire EDM titanium alloys for a specific response (high MRR). Wire cutting or wire cutting is an electrically conducting erosion method for the development of a dynamic two- or three-dimensional system [9]. The A DC power supply circuit sends a super frequency voltage pulse to the wire and piece of equipment with a broad wire diameter of 0.05-0.25 mm in WEDM. The split between the cable and the workpiece flows with deionized dielectric water. Parametric optimization of wire dissipation (WEDM) methods was studied by Taguchi system for measuring on surface finish (Ra) and MRR [10]. The average volumetric potential for the WEDM of the Ti-6Al-4V titanium alloys was 17.75mm3 per min, 18% greater than for an uncoated brass electrode and 16% greater than for a zinc-coated electrode. The perfect mix of mechanical parameters. The importance of process parameters, and different operations conditions on the wide cone, RMR, surface topping and surface topography have been emphasized. Machine power (4 mm / min), wire speed (8 m / min), wire voltage (1,4 kg) and Voltage (60V) [11]. Taguchi's method for designing L36 mixed orthogonal array (21× 3 8) of titanium is shown in table 1.

Table 1. Process parameters of WEDM method [12]

Parameters	Units	Level 1	Level 2	Level 3
Dielectric conductivity (DC)	mho	10	14	
Pulse width (PW)	µs	0.6	0.8	1.2
Time between pulses (TBP)	µs	5	13	21
Maximum feed rate (MFR)	micron/ min.	2	12	22
Servo Control mean Reference Voltage (SCMRV)	volts	20	40	60
Short Pulse Time (SPT)	µs	0.2	0.4	0.6
Wire Feed Rate (WFR)	m/min	4	8	12
Wire Mechanical Tension (WMT)	daN	0.5	1.5	2.5
Injection Pressure (IP)	bars	2	3	4

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IV. Effect of machine feed rate:

In the WEDM phase, a series of separate chokes between the workpiece and an electrical tool (Small Wire) erodes the material. Such electrical discharges melt and spray small amounts of the working material that the di electric device then expels and flushes away. As there is no mechanical interaction between the component and electrode, WEDM can be used to process material conduction independently of its hardness and hardness [13]. It is made of thin, cotton or covered wire with a diameter of 0,05-0,3 mm and an electrode that is constantly moving. A challenging challenge in WEDM is to select suitable machining parameter combinations for high precision because of the method variables and the complex processes of the operation. Principally, substrate oxidation determines the strength of the fire. Feed rate increases; MRR increases as well until it is optimized [14]. Parallel changes in MRR resulted from the rise in the machine feed volume. Nihat Tosun et al. stated that open circuit voltage was around three times higher than that of the Open Circuit Voltage when it is MRR regulated. MRR was found to have open circuit voltage with pulse duration and less efficient wire velocity and dielectric flushing pressure [15].

V. Surface roughness:

Surface roughness (Ra) is a measurement of surface quality. One important element in workmanship is the predictability of results. A smooth surface can be achieved with a small device feed rate [16]. Wire and spark gap stresses are measured so that critical parameters can achieve a better surface finish. It is because the wire voltage rises that decreases the vibration of the machined component and improves its surface quality. With increasing voltage, it strengthens the electric field and increases the spark discharge. This is more efficiently applied at the same distance and has a rough coating [17]. Abdulkareem et al. have shown the possibility of use of wet WEDM for improving titanium surface roughness (Ti-6al-4V). The measurement of surface roughness is depicted in figure 2.

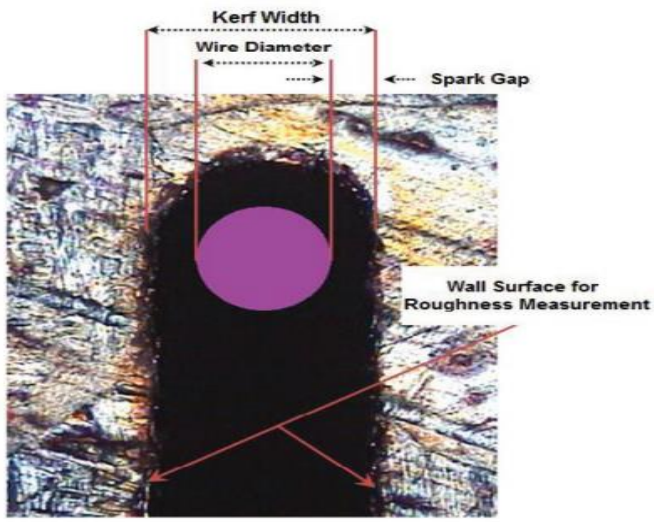

Figure 2. Measurement of surface roughness [18]

VI. Residual stresses:

The inhomogeneous temperature distribution and dielectric fluid quenching effect create the machined surface with the residual stresses. In most cases, however the surface stress and maximum tensile maximum under the surface, irrespective of material and the conditions, are caused by all EDM (Die-Sinking EDM and wire EDM) process [19]. In key cuts and rough cuts and finishes cut to oils and hydro shapes, the stresses were extremely tensile with small patterns of profiling and measurements on both sides. The residual stresses are almost identical in parallel and perpendicular to the wire. It should be pointed out that the first three residual stress measurements cannot be exact on the main cut surfaces because of the major impact of a high robustness. Dielectric vaporized and molten matter was quickly drained and solidified [20]. The bulk content below limits the shrinking, resulting in high residual tensile tension on the heat zone (HAZ) as the strong substance tends to shrink on the top surface [21]. For the measurement of the HAZ field a tensile residual stress depth is used on the soil. For principal cut, raw cut and finish trim, HAZ area is 30μm, 20μm and 5μm respectively. The dielectric vapour is 27μm, 17μm and 7μm thick. To decrease the depth of HAZ, the finishing cut is obviously required. A decrease in oil dielectric trim levels is due to the marginally deeper HAZ region [22]. A detailed study of residual stresses on titanium alloys have been presented for plasma arc welding process [23-24].

VII. Conclusion:

Over the last few years, EDM has brought a lot of improvement to the process. EDM has become one of the most common processes because of the ability to machine complex parts and hard material. A systematic literature review of EDM, WEDM advanced materials and parameters reports from researchers was presented in this paper. The study of these articles showed that researchers used different types of alloys based on titanium. Details on the subsurface adjustments during the WEDM of Ti-based alloys are inadequate. The specific instruments and techniques the researchers use. This paper presented important contributions of the research on titanium EDM and WEDM. The further work will significantly develop the capabilities of WEDM method to increase the quality, accuracy and performance of machining. To reduce the inaccuracy caused by vibrational or static deflection of wire, mathematical models have to be developed.

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