Analysis And Design of Zinc Coated Brass Electrode Wires on The Surface of WEDM Cut Component

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Abstract: The term 'refractory metal' is used to describe a class of metal elements that have exceptionally high melting points and are resistant to corrosion, wear and deformation. Wire EDM Machining (also known as Spark EDM) is an electro thermal production process in which a thin single-strand metal wire (usually brass) in conjunction with de-ionized water (used to conduct electricity) allows the wire to cut through metal by the use of heat from electrical sparks. a thin single-strand metal wire, usually brass, is fed through the workpiece, submerged in a tank of dielectric fluid, typically deionized water. Wire-cut EDM is typically used to cut plates as thick as 300mm and to make punches, tools, and dies from hard metals that are difficult to machine with other methods.

Key Words: —*De-ionized water, WEDM, EDM.*

I. Introduction

Wire EDM also gives designers more latitude in designing dies, and management more control of manufacturing, since the machining is completed automatically. Parts that have complex geometry and tolerances don't require you to rely on different skill levels or multiple equipment. Substantial increases in productivity are achieved since the machining is untended, allowing operators to do work in other areas. Most machines run overnight in a "lights-out" environment. Long jobs are cut overnight, or over the weekend, while shorter jobs are scheduled during the day. Most workpieces come off the machine as a finished part, without the need for secondary operations. It's a one-step process. The WEDM machine involves a primary worktable (X-Y) on which the work is clamped; an auxiliary table (U-V) and wire drive mechanism. The primary table moves along X and Y-axes and it is driven by the D.C. servo motors. The wire which is traveling, is fed continuously from feed spool and is gathered on take up spool which is moving through the work and is under tension between wire guides located on the other side of the work.

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The lower wire guide is stationary whereas the upper guide which is supported by U-V table, manage to displace with respect to lower guide along U and V axis transversely. By movement of quill, upper guide can be positioned along Z axis vertically.

The electro erosion of the work material is caused by a progression of electrical pulses generated by pulse generating unit which is being applied between the work and the travelling electrode. As the procedure proceeds, the worktable carrying the work is displaced transversely in a path which is predefined and is programmed in X-Y controller. During continuous machining operation, continuous flushing of machining zone is performed through water passing from nozzle at both sides of the work. Since water is utilized as a dielectric medium, it is imperative that water does not ionize. Consequently, keeping in mind the end goal to keep the ionization of water, an exchange ion resin is utilized as a part of the dielectric distribution process to keep up the conductivity of water.

II. Related Work

The analysis [1] introduce that the study the effect of wear parameters like applied load, sliding distance and sliding speed on the dry sliding wear of Niobium C-103 refractory alloy. Wear tests of Niobium C-103 alloy are carried out on pin on disc wear testing machine by varying the sliding speed, sliding distance and applied load. The effect of these parameters on wear rate has been determined by using

ANOVA analysis, which shows that wear rate is mainly affected by load and then sliding speed and sliding distance. The experimental results were used to construct artificial neural network. Two layer and three-layer feed forward network with back propagation technique was used for modeling of ANN.

In this paper [2], focus of this work was to study the effect of cutting parameters – speed, feed and depth of cut on the machinability of Niobium C-103 under dry machining condition using response surface methodology (RSM). In present study various machinability models were developed. This machinability models defined a functional relationship between cutting variables and response (Cutting Temperature). Cutting levels for experimentation was selected based on the cutting insert manufacturer recommendations. The analysis shows that Cutting speed is the most evident factor for cutting temperature.

This paper [3] introduced on advancing the wire electrical discharge machine (WEDM) process parameters for the normal surface roughness (Ra) acquired in machining of VANADIS 4e (Powder metallurgical cold worked Tool steel). The Machining analyses were performed at WEDM machine utilizing 0.25 mm coated brass wire as electrode material on p/m cold worked tool steel. Taguchi L27 orthogonal array (OA) was utilized to outline of trial. Ideal methodology parameters were resolved utilizing the signal- to- noise (S/N) proportion which was computed for Ra as per "smaller-the-better" approach. The methodology parameters of WEDM procedure were pulse on time, pulse off time, servo voltage, peak current, wire tension and water pressure. The impacts of the methodology parameters on surface roughness were assessed by the examination of change (ANOVA). The surface roughness increases with increase in pulse on time and peak current and decreases with pulse of time, spark gap set voltage and wire tension.

The Paper [4] mentioned the degradation mechanisms relevant to hypersonic environments have been investigated for silicide-coated niobium alloys. To assess the suitability of silicide coatings for possible leading edge, scramjet combustor, and vehicle acreage applications, tests were conducted over a range of oxygen and water vapor partial pressures. X-ray diffraction was used to characterize the composition of oxide phases. Chemical compositions of both the coatings and resulting oxides have been examined using energy dispersive x-ray analysis. Partial pressures of oxygen and water vapor have been found to influence the oxide composition, which may include silica, chromia, iron niobate, and chromium niobate phases. The formation of volatile oxide and hydroxide species also affects oxidation behavior and coating performance. Thermodynamic models of oxidation and volatilization are used to interpret experimental results.

The paper [5] shows refractory metals that exhibit significant oxygen solubility can harden and/or embrittle at low oxygen pressures without formation of a significant oxide layer. However past studies have shown that the addition of alloying elements, especially those that have a strong affinity for oxygen (e.g.,Ti, Zr, Hf) significantly alter morphology of oxides and thus, the mechanical properties at a given oxygen concentration. Niobium based alloys used commercially generally contains very high reactive additions such as Hf, Zr and Ti. Although niobium oxides have very large negative free energy of formation, the free energies of Hf, Zr, Ti oxides are even more negative. Thus, one can expect that niobium alloy containing these solutes should internally oxidize during heat treatment at vacuum levels of1×10^{-3} Pa. Because mechanical properties can be influenced markedly by formation of precipitates, there is practical interest in the internal oxidation of niobium-based alloys. The objective of the present work is to study the effect of internal oxidation on the microstructure and mechanical properties of C-103 alloy. Tensile specimens and test coupons of alloy containing different levels of oxygen (100–2500 ppm) were characterized with respect to microstructure and mechanical properties

The analysis [6] introduce the attempt has been made to analyze the machining conditions for Material Removal Rate (MRR), Surface Roughness (SR), cutting width (kerf) and dimensional deviation during WEDM of Inconel 718 using DoE such as Taguchi methodology, L8 Orthogonal Array. The experimental analysis is carried out using Minitab 16 software and it was observed that pulse-on-time is the most influential factor for all the response variables such as MRR, SR, Kerf and dimensional deviation at 95 % confidence level, with contributions of 54.32 %, 58.42 %, 83.21 % and 36.11 % respectively. Along with this, peak current was observed to be next significant parameter for kerf and dimensional deviation whereas for MRR and SR servo voltage was observed to be the next significant parameter. Dimensional deviation is affected by increase in pulse on time, peak current, wire feed and spark gap set voltage. However, increasing pulse off time and wire tension found to be improving dimensional deviation.

III. Problem Statement

Surface roughness quantification was done by utilizing a portable stylus-type profilometer (Taylor Hobson, Surtronic-3+) as shown in figure. The profilometer was set to a cut-off length of 0.8mm and 4mm valuation length. The least count of the profilometer is 0.01 micron.

3.1 Proposed Design

3.1.1 Parameters

Input parameters:

We have taken four input parameters with initial range as shown in the table:

Input parameters	Range
Pulse on time (A) TON	104-112 µs
Pulse off time (B) TOFF	56-62µs
Peak current (C) IP	10-12A
Gap voltage (D) SV	8-10V

3.2 Scanning Electron Microscopy (SEM) Analysis

3.2.1 Niobium C-103 without WEDM machining

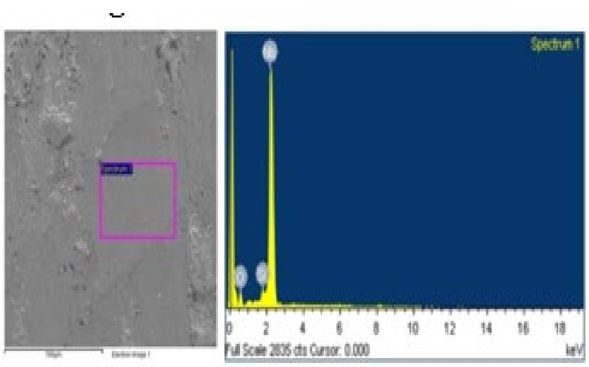

Fig.1.SEM for un-machined workpiece

IV. Results

Mean plots for surface roughness with brass wire are shown in figure 4.21 which indicate SR increases with increasing levels of TON and IP, SR decreases with increasing levels of TOFF.

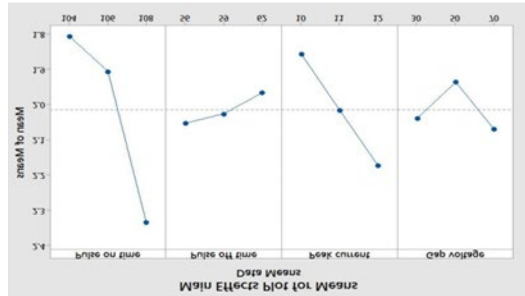

Fig.2. Surface roughness mean plot for Brass wire

V. Conclusion

In this study, the effect of process variables on response measures (SR) of S7 Niobium C 103 was investigated experimentally in WEDM. Also, a comparative study is carried out to know the effect of different electrode wires (brass wire and zinc coated brass wire) on the output values.

- Pulse on time (TON) is the most significant factor for surface roughness for machining with both brass wire and Zn coated brass wire with 71.01% and 64.05% contribution in mean.
- From SEM micrographs it is observed that surface Roughness with Zn coated brass wire is less compared to brass wire.
- Increase in discharge current and pulse duration causes a significant increase in discharge energy which in turn affects the SR by increasing spark diameter and the depth of discharge craters.
- At optimum levels for brass wire SR is obtained with 4.4% error and for Zn coated brass wire SR is obtained with 2.4%.

Comparing both wires, Zn coated wire is giving more optimum results with lesser surface roughness at same levels of input parameters.

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