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Surface Integrity Analysis of Machined Surface After Rough Cutting Operation In Wedm

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Abstract:- *WEDM process removes the work-materials by a series of electrical sparks between the workpiece and wire electrode. These sparks generate craters, recast layers and heat-affected zones on the subsurface of the machined workpiece. Machined surface with poor surface integrity is a major disadvantage of WEDM. After rough cutting operation in WEDM, some surface area remains uncleared on work surface in intricate machining such as in die making. This paper presents a study of uncleared materials named as surface projection, in die making after rough cut in WEDM. Using SEM images, length of uncleared surface projections have been measured. Results show that level of discharge energy is greatly influence the surface projections made on machined surface.*

Keywords:- *Nimonic 90, Wire Electrical Discharge machining (WEDM), Discharge energy, scanning electron microscope (SEM).*

I. Introduction

Wire electrical discharge machining is an electro thermal process, which removes electrical conductive materials by mean of repetitive electric sparks discharge from a pulsating DC power supply across a spark gap between a continuous moving conductive wire and work piece (Figure 1). Each discharge melts or vaporizes a small amount of materials from the machined surface which is flushed away by the dielectric fluid flowing between wire electrode and machined surfaced. WEDM provides the best alternatives for machining the exotic, conductive and hard materials with the scope of generating intricate shape and profile [1].

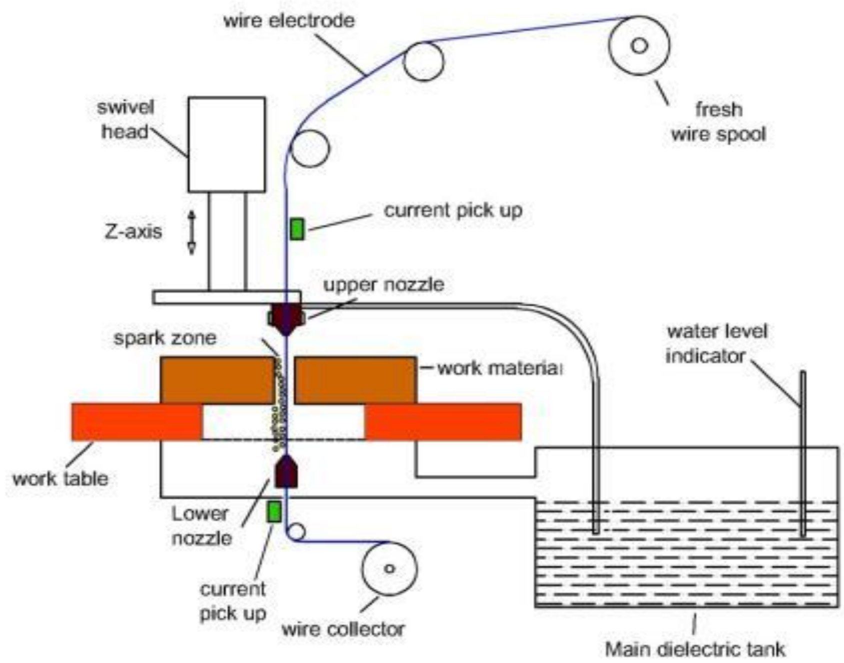

Fig 1: Wire Electrical Discharge Machining (WEDM) process

In past, several investigations have been carried out to optimize the WEDM process by various approaches. Hewidy et al. [2] developed a mathematical model based on response surface methodology (RSM) for correlating the interrelationship of various WEDM machining parameter for Inconel 601 such as Discharge energy, duty factor, wire tension and water pressure on machining performance characteristics such as material removal rate (MRR), wear ratio and surface roughness (SR). Jangra et al. [3] utilized the grey based Taguchi method to optimize the MRR and SR for WEDM of WC-Co composite. Results revealed that taper angle, pulse on time (Ton) and pulse off time (Toff) were found the most significant process parameters. The majority of past research work focuses on rough cutting operation in WEDM. Damaged surface layer with poor surface integrity, micro cracks, heat affected zone are the major shortcoming in rough cutting operation [4-5].The defects are due to high heat energy generated across the electrodes and re-solidification of melted debris's that do not flushed quickly out of a narrow spark gap [6-8]. Jangra et al. [9] conducted an experimental study on rough and trim cutting operation in WEDM of four hard to machine materials namely WC-Co composite, HCHCr steel alloy, Nimonic-90 and Monel-400. Result shows that using single trim cutting operation with correct machining parameters and appropriate wire offset, surface characteristics can be improved irrespective of the rough cutting operation. Despite many research works on WEDM, not much literature is available on uncleared materials after rough cutting operation in die cavity. It is very important to minimise this uncleared materials in order to achieve good die performance and quality of the final components. Therefore, the aim of this paper is to present some investigations on surface projections appeared after rough cutting operation in intricate machining on WEDM.

II. UNMACHINED AREAS

In case of rough cutting operation, SEM images show some surface area remains uncleared at the end of rough cut in die cavity on WEDM. The movement of wire electrode starting form point 0 is shown by the direction of arrow as shown in Figure 2. Wire electrode completes the cutting operation at point B before reaching point A. Therefore, a triangular shape unmachined surface has been formed inside the cavity. The area of the unmachined surface depends mainly on discharge energy across the electrodes.

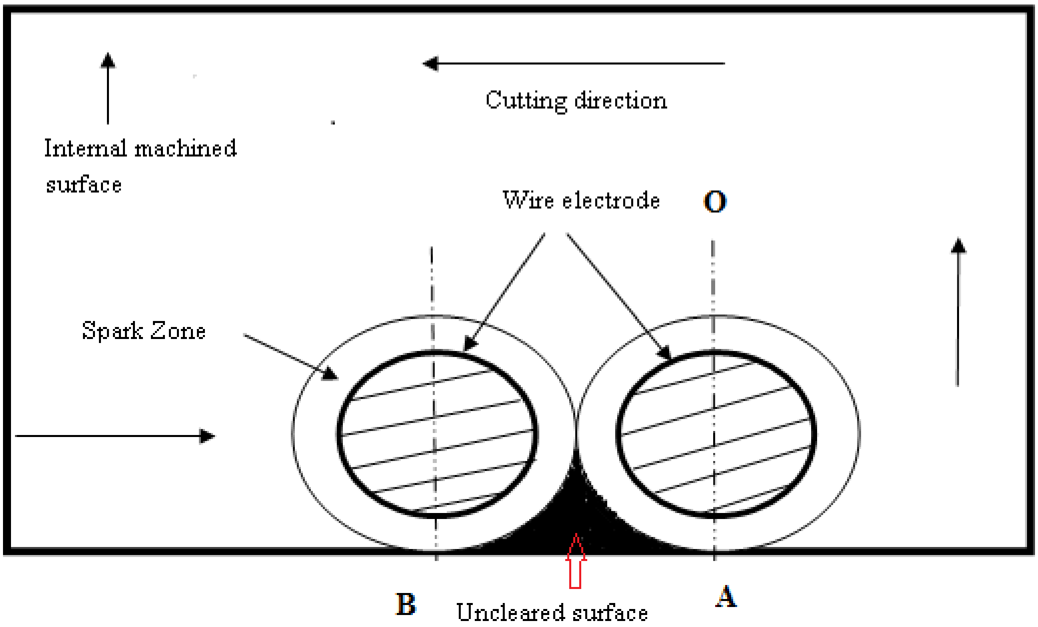

Fig 2: Representation of unmachined surface area in WEDM

III. EXPERIMENTATION

In present work, Nimonic-90 has been selected for conducting experiments on 5 axis sprint cut (ELPUSE-40) Wire EDM manufactured by Electronic M/C Tool LTD India. Nimonic-90, a nickel based super alloy containing 60% Ni, 19.3% Cr, 15% Co, 3.1% Ti, and 1.4% Al, hot forged in rectangular plate of 12.5 mm thickness; has been selected as work piece material. It has density; 8.18 g/cm^3, melting point; 1370 ^{0}C, hardness;

361 HV, thermal conductivity; 11.47 W/mĊ and modulus of elasticity; 220MPa. The major characteristic of Nimonic-90 is its high rupture strength and creep resistance at high temperature (upto 900^0C). In present experimentation, rough cutting operations were performed at different combination of process parameters. Using WEDM, work material was machined and samples were obtained in the form of rectangular cavity of dimension 6 mm × 10 mm × 12.5 mm. A zinc coated brass wire having a fixed diameter of 0.25mm has been selected as wire electrode. A constant value of 5 m/min has been assigned to wire feed rate with adequate wire tension of 10N. All experiments were conducted at zero wire offset value. Distilled water having conductivity 20 mho with high value of flow rate 12 litres per minute (LM^{-1}) has been utilised in present study.

IV. RESULTS AND DISCUSSION

WEDM is a specialized thermal machining process in which electrical sparking occurs as a result of ionization of dielectric particles between the electrodes and give to extreme temperature rise between 8000C° to12000C° causing fusion of the workpiece material. As results, the thermal stresses are developed causing large size craters, micro-cracks and hollow cavity on machined work surface at high discharge energy level in rough cutting operation as shown in Figure 3. Main concentration of this study is focus on surface projection made inside the die cavity in rough cutting operation. In order to examine the extent of surface projection on machined surface, photographs of transverse section of die cavity were taken through SEM.

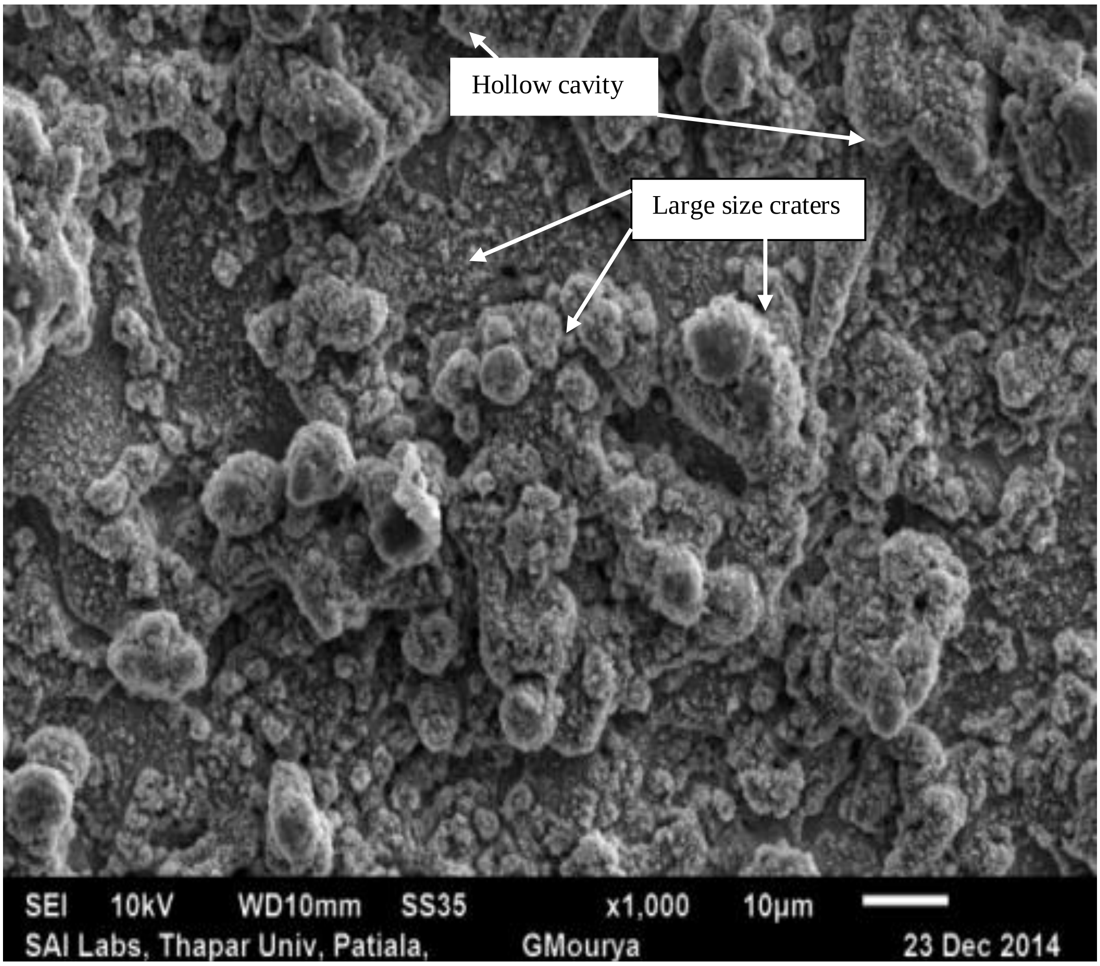

Fig 3: SEM images of the top view of inside surface of the die cavity at high discharge parameters (Ip: 150 A; Ton: 118μs; Toff: 45μs; 30 V)

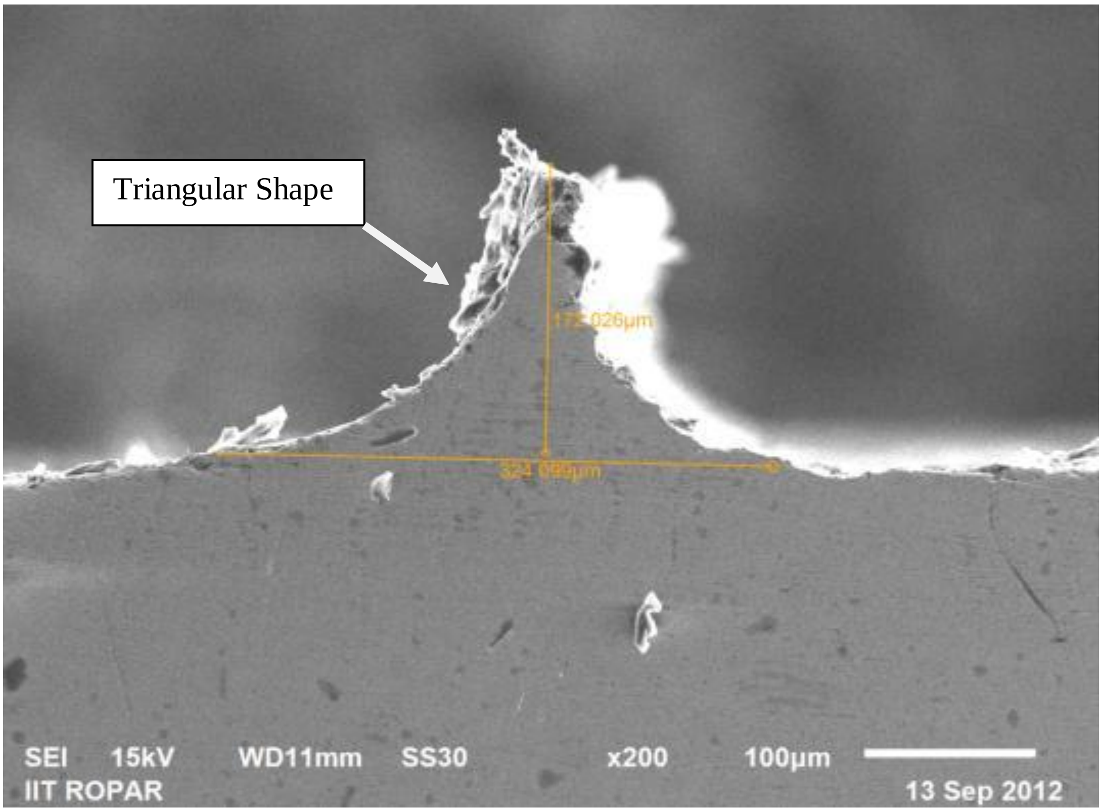

Fig 4: SEM micrograph of machined surface (Ip: 90 A; Ton: 106 µs; Toff: 45 µs; SV: 50V)

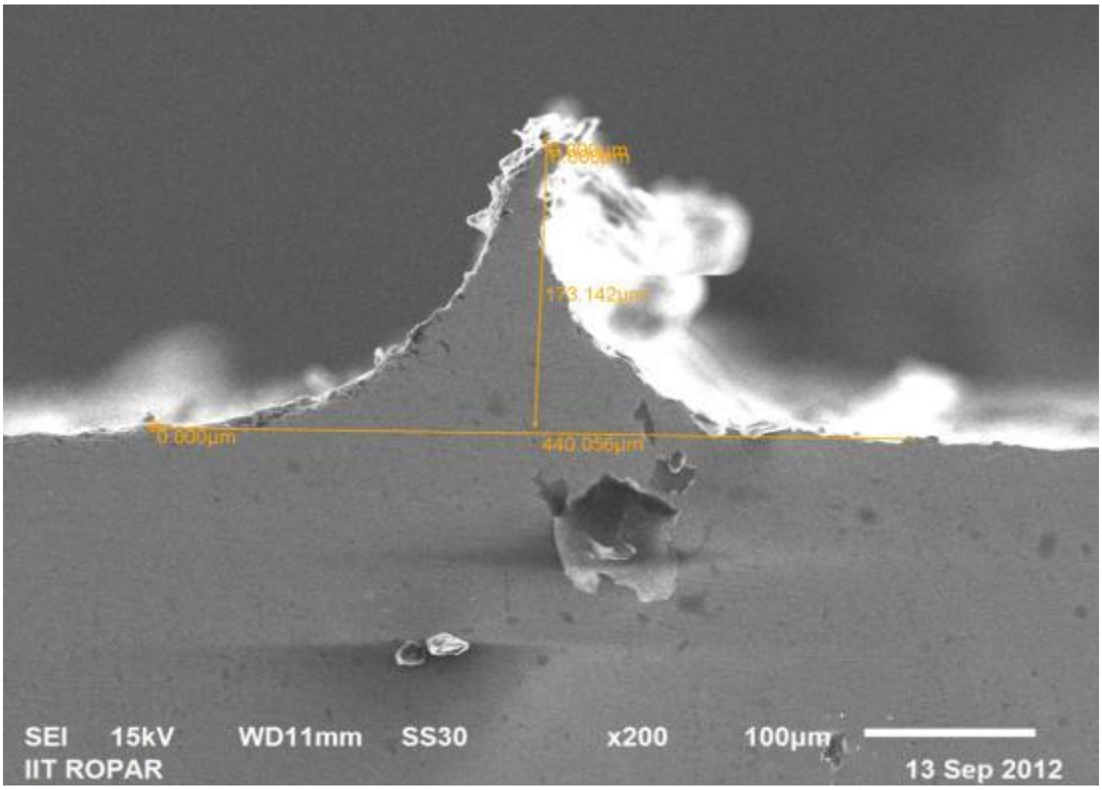

Fig 5: SEM micrograph of machined surface (Ip: 120 A; Ton: 106 µs; Toff: 40 µs; SV: 50V)

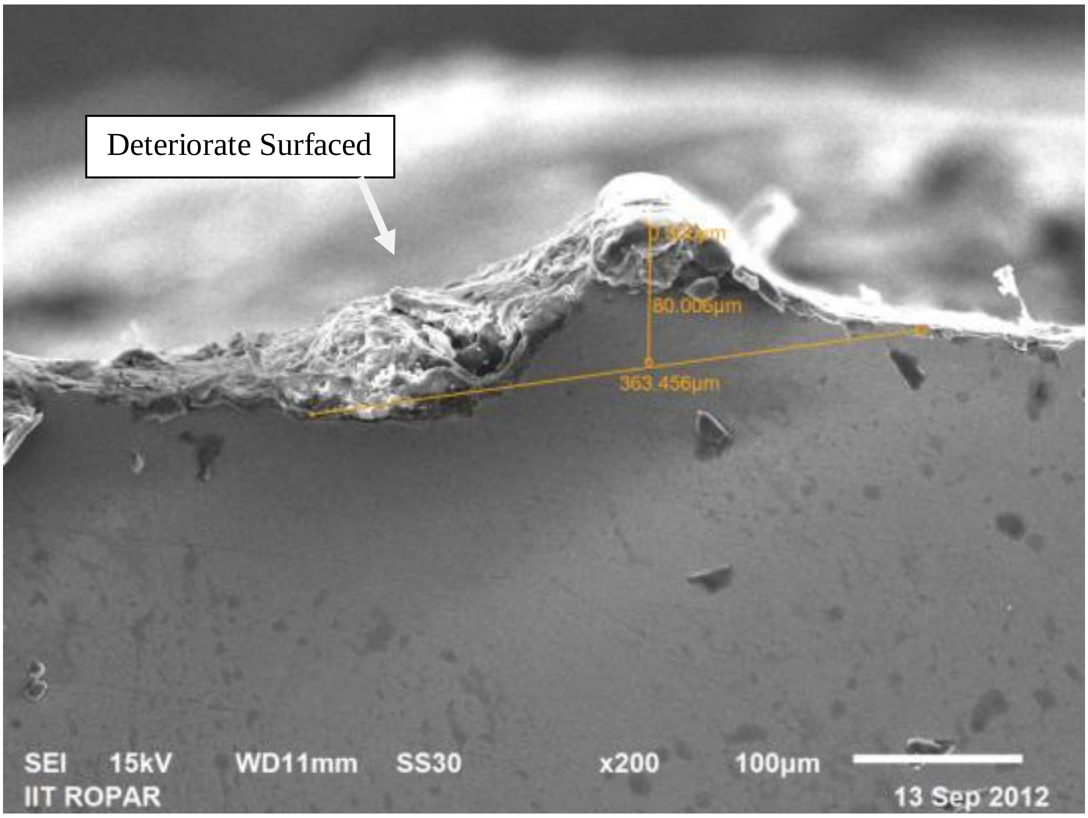

Fig 6: SEM micrograph of machined surface (Ip: 120 A; Ton: 118 µs; Toff: 30 µs; SV: 40V)

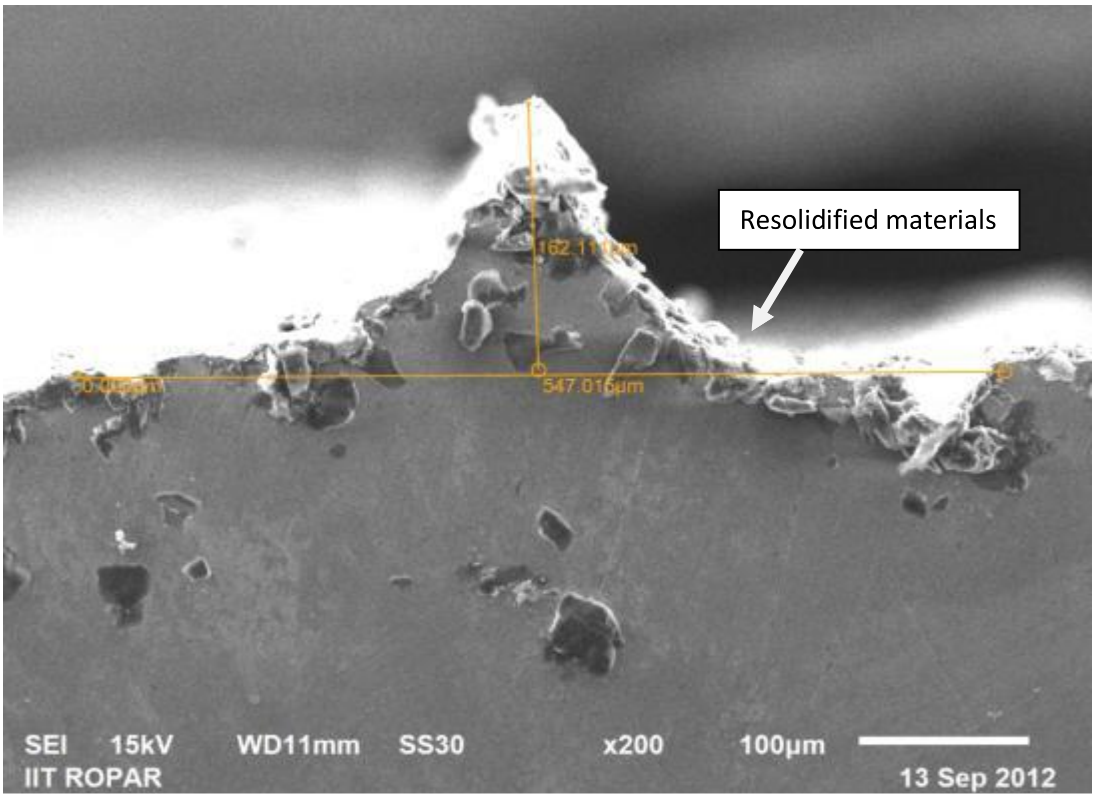

Fig 7: SEM micrograph of machined surface (Ip: 150 A; Ton: 118 µs; Toff: 45 µs; SV: 30V)

Shape of the unmachined top surface area generally, appears in a triangular shape but it may deteriorate depending on the discharge conditions i.e. peak current and pulse duration [10]. At low discharge energy, materials are removed from the machined surface at low cutting speed. So that, a sharp triangular shape is formed with greater height is observed as shown in Figure 4-5. Whereas, the increase in peak current increases the spark diameter which increases the length of ridge line but decrease the height of triangular shape. Increase in peak current and pulse on time deteriorate the shape and length of ridge line which is mainly due to large melting and increasing recast layer as shown in Figure 6-7. Long pulse on time at high peak current erodes more material form work surface which may cause re-deposition of melted material because of incomplete flushing of debris out of the spark gap, resulting into deteriorated ridge line.

V. CONCLUSIONS

The uncleared surface area (named as surface projection) in WEDM of Nimonic 90 was investigated in case of rough cutting operation. Using the SEM images compared the sizes of surface projections of specimens machined at low and high discharge energy. It is found that lengths of ridge line are function of two main discharge parameters i.e. peak current (Ip) and pulse on time (Ton). Increase in peak current and pulse on time deteriorate the shape and length of ridge line. These affect the surface quality and dimensional accuracy of the machined components.

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