iJRASET
International Journal For Research in Applied Science and Engineering Technology

# INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

**Volume:** 14 **Issue:** V **Month of publication:** May 2026

**DOI:** https://doi.org/10.22214/ijraset.2026.82204

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
*ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538*
*Volume 14 Issue V May 2026- Available at www.ijraset.com*

# Experimental Investigation and Optimization of WEDM Process Parameters for Al7075-SiC-Graphite Hybrid Composite Based on Surface Roughness and Material Removal Rate

Rekadi Srinivasa Rao[1], Mr. Dangeti Mahesh[2], Mr. K.V. Ramana Murthy[3]
*Department of Mechanical Engineering, Srinivasa Institute of Engineering and Technology, Cheyyuru*
*[1]PG Scholar, [2]Assistant Professor, [3]Associate Professor Department of Mechanical Engineering, Srinivasa Institute of Engineering and Technology Cheyyuru, JNTUK*

***Abstract:*** ***Now-a Wire Electrical Discharge Machining (WEDM) is an advanced non-traditional machining process extensively used for fabricating intricate and high-precision components from difficult-to-machine materials. In this study, an experimental investigation is conducted to analyze the influence of key WEDM process parameters on surface roughness (SR) and material removal rate (MRR) during machining of an Al7075-based hybrid composite reinforced with silicon carbide (7.5%) and graphite (2%). The primary process parameters considered include pulse-on time, pulse-off time, servo voltage, and wire feed rate, each varied at three levels. Experiments were systematically designed using the Taguchi method with an L9 orthogonal array to ensure efficient experimentation and reliable analysis. Other machining conditions such as wire diameter (0.3 mm), peak current (1.1 A), dielectric medium (distilled water), and wire tension (7 kgf) were maintained constant. Statistical analysis was carried out using Minitab software to evaluate the significance and contribution of input parameters on SR and MRR. The results reveal that pulse-on time and servo voltage significantly influence machining performance. An optimal combination of process parameters was identified to achieve improved surface quality and enhanced material removal rate. The findings of this study provide valuable insights into the optimization of WEDM parameters for hybrid composite materials, contributing to improved productivity and surface integrity in advanced manufacturing applications.***

***Keywords: Wire Electrical Discharge Machining (WEDM), Surface Roughness (SR), Material Removal Rate (MRR), Al7075 Hybrid Composite, Taguchi Method, Process Parameter Optimization, Minitab.***

## I. INTRODUCTION

A machining technique is usually used for hard metals, electric discharge machining (usually called "EDM Machining") sorts it likely to figure with metals that olden machining method machining are un successful. A critical purpose to recall with Electric discharge machining is that it is all entirely work with things that which are electrically semi conducting. That which are sensible Electric Discharge Machining equipment it is likely possible to chop tiny odd shaped angles, expanded contours or cavities in toughened steel likewise as exotic metals like Ti, hastelloy, kevlar, Inconel, and some of the inorganic compound. The methods of electric discharge machining is frequently employed in the tool and die business for mold making, therefore in the current years electric discharge machining has been an essential half for producing model and manufactured elements. That this is frequently seen within the area and natural philosophy industries where as production quantities halt low.

Fig1: Wire cut EDM Machine

 

## II. LITERATURE REVIEW

Within the paper by Atul Kumar, etal [2], variation of cutting performance with pulse on time, pulse off time, open voltage, feed rate override, wire feed, servo voltage, wire tension and flushing pressure were through an experiment investigated in wire spark machining (WEDM) method. Brass wire with zero.25mm diameter and Skd sixty-one steel with10mm thickness were used as tool and work materials within the experiments. The cutting performance outputs thought-about during this study were material removal rate (MRR) and surface roughness. Experimentation has been completed by exploitation Taguchi L18 (21 completely different conditions of parameters. optimum mixtures of parameters were obtained by this system. The study shows that with the minimum variety of experiments the entire downside are often resolved when put next to full factorial style. The results obtained area unit analyzed for the choice of associate optimum combination of WEDM parameters for correct machining of Skd sixty one alloy to attain higher surface end. Additionally the importance of the cutting parameters on the cutting performance outputs is decided by exploitation analysis of variance (ANOVA) L37 orthogonal array.

## III. OBJECTIVE

Here in this thesis we are going to investigate the effect of various parameters used in wire cut EDM process on MRR and surface roughness to obtained the optimal set of parameters on the machined work piece Soheretheexperiments areconductedonthecompositeworkpiecematerialusingtherespective parameters i.e., pulse on time - 100µsec, 150 µsec, 200µsec & Pulse Time off – 52µsec, 56µsec, 60µsec, servo voltage – 30V, 50V, 70V & Wire Feed – 2mm/min, 3mm/min, 4mm/min. Other parameters are kept constant such as Wire dia - 0.3mm; peak current – 1.14Amp and Coolant is Distilled water, Wire Tension – 7Kgf.So the optimization process is done using taguchi technique using Minitab software.

## IV. EXPERIMENTAL SET UP AND PROCEDURE

The selected work piece materials for this research work are composite work piece material. Experiments have been conducted on Wire Cut EDM. The machine details are:

WIRE EDM CNC SPRINT CUT 734 (ELECTRANICA SPRINT CUT 734), Make: ELECTRIONCA LTD, PUNE


Fig2: Wire cut EDM Machine setup

According to the Taguchi Method here the below table represents the L09 Orthogonal Array

| JOB NO | PULSETIME ON (µsec) | PULSETIME OFF(µsec) | SERVO VOLTAGE(V) | WIREFEED (mm/min) |
|---|---|---|---|---|
| 1 | 100 | 52 | 30 | 2 |
| 2 | 100 | 56 | 50 | 3 |
| 3 | 100 | 60 | 70 | 4 |
| 4 | 150 | 52 | 50 | 4 |
| 5 | 150 | 56 | 70 | 2 |
| 6 | 150 | 60 | 30 | 3 |
| 7 | 200 | 52 | 70 | 3 |
| 8 | 200 | 56 | 30 | 4 |
| 9 | 200 | 60 | 50 | 2 |

Table1: Generated L09 Orthogonal array through Taguchi method

EXPERIMENTATION PHOTOS:


Fig:3 Wire Cut EDM Machine

Fig4: Parameters display panel

Fig5: Piece before Machining

Fig6: Machining of Piece

Fig7: Final machined pieces

Fig8: Hardness tested work piece

The observed surface roughness values during testing:

| ob no | Pulse time on (µsec) | Pulse time off (µsec) | Servo voltage (v) | Wire feed (mm/min) | Surface roughness $_1$µm | Surface roughness $_2$µm |
|---|---|---|---|---|---|---|
| 1 | 100 | 52 | 30 | 2 | 3.84 | 3.46 |
| 2 | 100 | 56 | 50 | 3 | 3.71 | 3.42 |
| 3 | 100 | 60 | 70 | 4 | 3.46 | 3.27 |
| 4 | 150 | 52 | 50 | 4 | 3.87 | 3.67 |
| 5 | 150 | 56 | 70 | 2 | 3.79 | 3.64 |
| 6 | 150 | 60 | 30 | 3 | 3.60 | 2.97 |
| 7 | 200 | 52 | 70 | 3 | 4.12 | 4.40 |
| 8 | 200 | 56 | 30 | 4 | 4.04 | 4.69 |
| 9 | 200 | 60 | 50 | 2 | 3.35 | 3.45 |

Table2: L09 parameters of surface roughness

Observed MRR values:

| S.No | JOB NO | PULSE TIME ON | PULSE TIMEOFF | SERVO VOLTAGE | Wire Feed (mm/min) | (mm$^3$/sec) |
|---|---|---|---|---|---|---|
| | (µsec) | (µsec) | (V) | (V) | | |
| 1 | 100 | 52 | 30 | 30 | 2 | 330.36 |
| 2 | 100 | 56 | 50 | 50 | 3 | 293.85 |
| 3 | 100 | 60 | 70 | 70 | 4 | 297.93 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 4 | 150 | 52 | 50 | 50 | 4 | 312.15 |
| 5 | 150 | 56 | 70 | 70 | 2 | 346.19 |
| 6 | 150 | 60 | 30 | 30 | 3 | 302.18 |
| 7 | 200 | 52 | 70 | 70 | 3 | 259.77 |
| 8 | 200 | 56 | 30 | 30 | 4 | 252.93 |
| 9 | 200 | 60 | 50 | 50 | 2 | 249.59 |

Table3: Observed MRR values

OPTIMIZATION PROCESS OF MACHINING PARAMETERS FOR MRRUSING MINITAB SOFTWARE
As here we are having 3 parameters for the4 process machining parameters we are selecting this

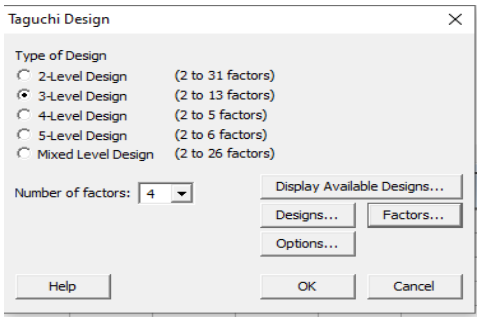


Fig9: Types of designs icon

Now we have to select the design factors option to enter the various machining and process parameters being used for the machining process

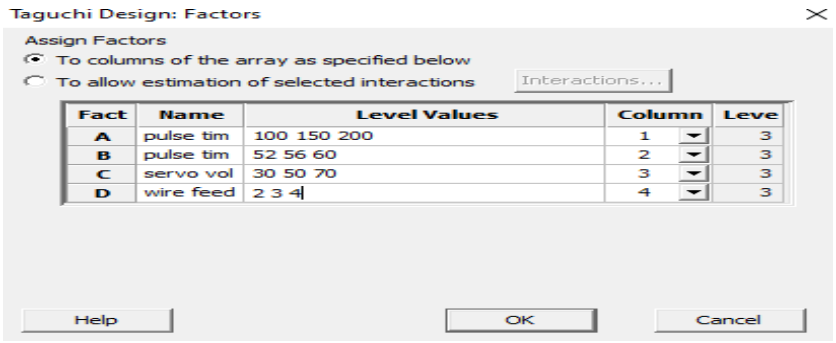


Fig10: Taguchi Design Factors

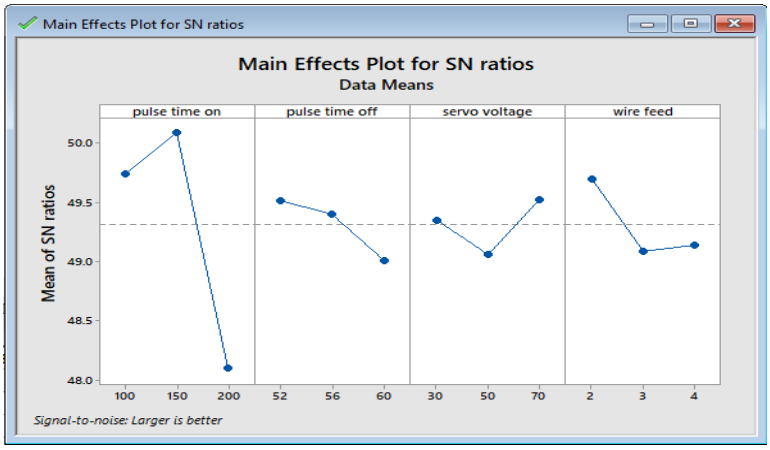


Fig11: Graph Main Effects Plot of SR for SN Ratios

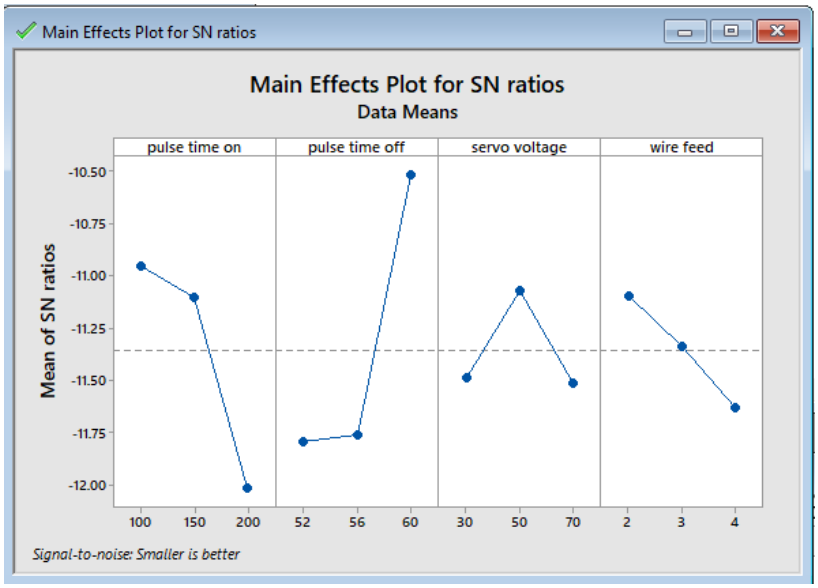

Fig12: Graph Main Effects Plot of MRR for SN Ratios

## V. CONCLUSION

Here in this thesis we are going to investigate the effect of various parameters used in wire cut EDM process on MRR and surface roughness to obtained the optimal set of parameters on the machined work piece. So here the experiments are conducted on the composite work piece material using the respective parameters i.e., pulse on time - 100µsec, 150 µsec, 200µsec &Pulse Time off – 52µsec, 56µsec, 60µsec, servo voltage – 30V, 50V, 70V & Wire Feed – 2mm/min, 3mm/min, 4mm/min. Other parameters are kept constant such as Wire dia - 0.3mm; peak current – 1.14Amp and Coolant is Distilled water, Wire Tension – 7Kgf.So the optimization process is done using taguchi technique using Minitab software.

So finally for the taguchi method, for the MRR here the optimal result is pulse on time is at 150µsec, pulse off time is at 52µsec, servo voltage should be set at 70V and wire feed has to beat 2mm/min

So when we consider the SR MRR here the optimal result is pulse on time is at 100µsec, pulse off time is at 60µsec, servo voltage should be set at 50V and wire feed has to be at 2mm/min

So when we have verified the hardness of this composite material (Al 6061 (90.5%) + SCi(7.5%)+Graphite(2%)) herewehaveachieved110BHN,whencomparedwiththebasematerial aluminum alloy block ranges form 75 – 89BHN.

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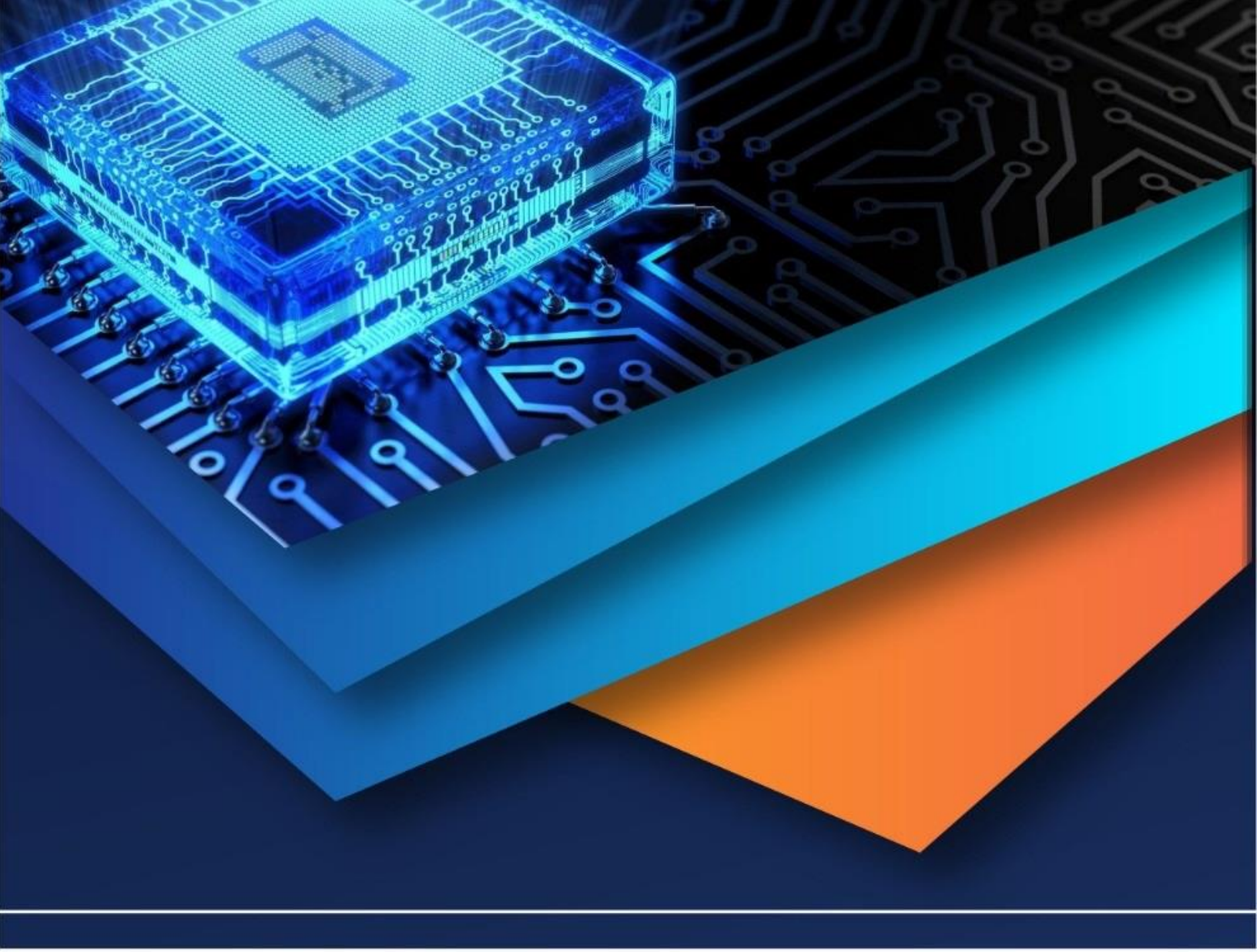

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