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Optimization of Machining Parameters of EN-27 Material Using Wire Electric Discharge Machining (WEDM)

Ritesh Fegade[1], Veerabhadrappa Sulepeth[2], Suraj Londhe[3], Balkrushna Bongale[3], Avinash Ushir[3] Sakshi Shelar[3,]*

Abstract

The optimization of Wire Electrical Discharge Machining (WEDM) parameters for EN-27 alloy steel, a high-strength material widely utilized in mechanical and structural applications, is the subject of this study's methodical analysis. Due to its hardness and poor machinability by conventional methods, WEDM is preferred for achieving precise dimensional accuracy and surface integrity. The primary objective of this work is to enhance machining performance by identifying optimal process parameters influencing Material Removal Rate (MRR) and Surface Roughness (SR). The experimental design was developed using the Taguchi method to minimize the number of experimental runs while ensuring statistical reliability. Four key machining parameters pulse on time, pulse-off time, voltage gap, and wire feed were selected as control factors. An L16 orthogonal array was employed to conduct the experiments, and the results were analyzed using Analysis of Variance (ANOVA) to determine the significance of each parameter on the selected responses. The experimental results indicate that pulse on time is the most influential parameter affecting MRR, as increased discharge duration leads to higher spark energy and enhanced material erosion. Voltage gap was also found to significantly influence both MRR and SR by regulating discharge stability and energy distribution. Pulse off time and wire feed exhibited relatively lower individual contributions; however, they play an important role in maintaining machining stability and surface quality. ANOVA results confirmed the statistical dominance of pulse-on time and voltage gap. The optimized parameter settings resulted in improved machining efficiency and surface finish, demonstrating the suitability of WEDM for machining EN-27 alloy steel in advanced manufacturing applications.

Keywords: WEDM, EN-27 steel, Taguchi method, ANOVA, MRR, surface roughness

***Author for Correspondence**
Sakshi Shelar
E-mail: shelarsakshi091@gmail.com

[1]Associate Professor, Department of Mechanical Engineering, Parvatibai Genba Moze College of Engineering, Pune, Maharashtra, India
[2]Assistant Professor, Department of Mechanical Engineering, Parvatibai Genba Moze College of Engineering, Pune, Maharashtra, India
[3]Student, Department of Mechanical Engineering, Parvatibai Genba Moze College of Engineering, Pune, Maharashtra, India

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INTRODUCTION

Wire EDM is a vital non-traditional machining process capable of manufacturing complex geometries in hard materials. EN-27 steel, known for its high strength and thermal conductivity, presents machining challenges in conventional processes. WEDM offers a feasible solution through precise control of spark erosion [1–3].

WEDM is a thermo-electrical technique in which unwanted material from work part is removed by continues sparkle between both work part and wire electrode [4–8]. The wire electrode which produced by thin copper, brass or tungsten are used in WEDM. In modern industries, very often, need to produce high strength, hardness, toughness and good wear and tear resistance and high temperature resistance alloys like titanium, Inconel, ceramics, zirconium, stainless steel, etc., for applicable in vehicles, aerospace, medical, defense, die and tool manufacturing industries. Machining of advanced materials by using conventional processes is difficult and sometimes impossible [9–12]. Thus, non-conventional methodologies are employed instead of traditional metal cutting methods for machine extremely high strength, hard and brittle work parts. Non-conventional machining techniques are distinguished as per principle used during processing of materials (Figure 1). WEDM is one such non-conventional process is which widely used for various applications [13–18].

Applications of Wire-cut EDM

WEDM method might be utilized to machine all major metals and metal alloys in use today. The use of It's particularly required for the correct manufacturing of forming tools, model components, small components and other highly specialized parts. It is a particularly effective and economic way for high strength alloys and for metals difficult to machine with the conventional metal removal processes. The WEDM method is highly used in modernized industry such as [19]:

- Aerospace industry
- Precision manufacturing industry
- Automobile industry
- Nuclear industry
- Naval
- Maintenance and repair works
- Chemical and Petro-chemical industries
- Aircraft and gas turbine plants
- Medical Appliance
- Jewelry industries

Abbreviations and Nomenclature

- WEDM: Wire Electrical Discharge Machining
- MRR: Material Removal Rate (mm^3/min)
- SR: Surface Roughness (µm)
- Ton: Pulse On-Time (µs)
- Toff: Pulse Off-Time (µs)
- VG: Voltage Gap (V)
- WF: Wire Feed (mm/min)

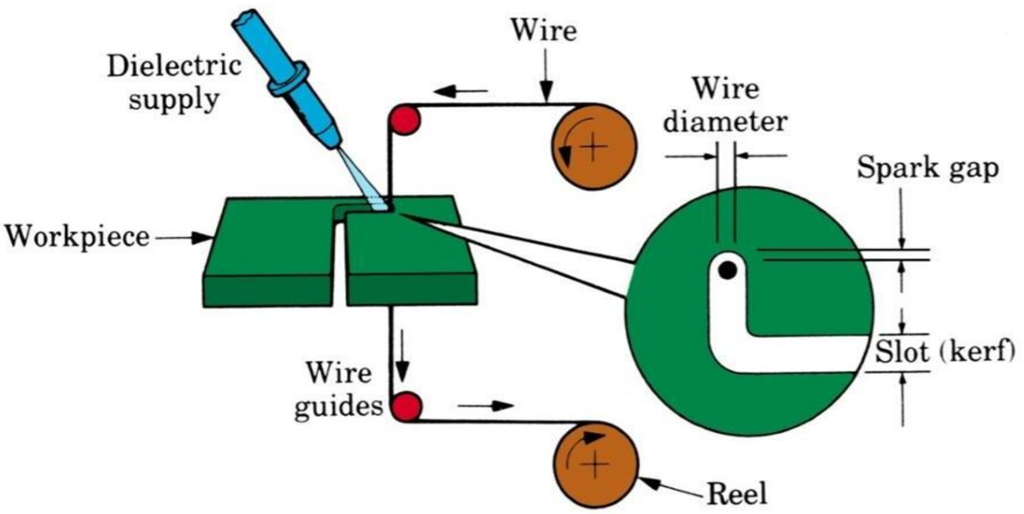

Figure 1. Schematic diagram of Wire Electrical Discharge Machining (WEDM) process.

Literature Review

Many researchers used Taguchi methods and ANOVA to study WEDM. Materials like Inconel, D2 steel, and EN-series alloys were tested. Studies show that input parameters like pulse on-time and voltage have a significant effect on output results [20–22].

Objectives

- To conduct experiments on EN-27 using WEDM
- To measure MRR and surface roughness
- To analyze and optimize input parameters using Taguchi and ANOVA

METHODOLOGY

An experimental matrix using Taguchi L16 orthogonal array was designed. Key input parameters included pulse-on time (Ton), pulse-off time (Toff), voltage gap, and wire feed rate. Output responses measured were Material Removal Rate (MRR) and Surface Roughness (SR). Statistical tools like ANOVA were used to analyze the influence of parameters.

Material Used

EN-27 steel was selected for its strength and industrial usage (Table 1).

Advantages of EN-27 Material

- High resistance to alkalis
- Good machinability
- High Corrosion resistance
- High thermal conductivity

Equipment

- WEDM machine
- Brass wire (0.25 mm diameter)
- Dielectric fluid: Water

Experimental Design

Taguchi L16 orthogonal array was used with four input parameters:

- Voltage gap (17–20 V)
- Wire feed (3–6 mm/min)
- Pulse on-time (116–123 μs)
- Pulse off-time (50–55 μs)

Output Responses

- *Material Removal Rate (MRR):* measured in mm^3/min
- *Surface Roughness (SR):* measured in μm

Table 1. Chemical Composition of EN-27.

Elements	Weight in %
Carbon	0.40/0.70
Silicon	0.28
Sulphur	0.013
Phosphorus	0.018
Manganese	0.40/0.70
Nickel	3.00/3.75
Chromium	0.50/1.30
Molybdenum	0.20/0.65

Analysis Tools

- Taguchi Method for optimization
- ANOVA (Analysis of Variance) using Minitab 16

RESULTS AND DISCUSSION

Taguchi analysis identified Ton and voltage gap as critical parameters influencing MRR and SR. ANOVA confirmed their statistical significance. Optimal levels resulted in enhanced material removal and smoother surface finish, indicating process efficiency.

- Higher pulse-on time increases the material removal rate (MRR) but deteriorates the surface finish.
- Voltage gap and wire feed also influence SR
- Optimal settings balance productivity and quality
- ANOVA showed pulse on-time has the most impact on MRR

CONCLUSION

Wire Electrical Discharge Machining (WEDM) has been demonstrated as an effective and reliable process for machining EN-27 alloy steel when appropriate machining parameters are carefully selected. The present study confirms that systematic parameter optimization significantly improves both machining efficiency and surface quality. The application of statistical tools such as the Taguchi method and Analysis of Variance (ANOVA) enabled a structured evaluation of the influence of process variables and facilitated the identification of optimal operating conditions with reduced experimental effort.

The results indicate that pulse on-time plays a dominant role in governing the material removal rate due to its direct influence on discharge energy, while wire feed also contributes significantly to machining stability and surface integrity. The optimized parameter combination resulted in enhanced material removal performance along with improved surface finish, thereby reducing the need for secondary finishing operations. The statistical validation provided by ANOVA further strengthens the reliability of the findings and supports their practical applicability.

Overall, this study establishes a clear relationship between WEDM parameters and machining performance for EN-27 steel. The optimized settings identified in this work can be effectively implemented in industrial environments to achieve higher productivity, improved surface quality, and better process control when machining EN-27 alloy steel.

DECLARATION OF INTEREST

The authors declare no conflict of interest.

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REFERENCES

1. Lin JL, Lin CL. Optimization of EDM process using grey relational analysis. Int J Mach Tools Manuf. 2002;42:237–244.
2. Fegade R, et al, (2025) "Advanced Machine Learning Models for Early Detection of Helical Gear Faults" International Journal on Interactive Design and Manufacturing (IJIDeM).
3. Ritesh Fegade, et al, (2025) "Innovative Magnetic Coupling for Enhanced Safety in Grinding Machines", Journal of Mines, Metals and Fuels,73(3),
4. ASTM D256 – 06. (2006). "Standard Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics."

5. Fegade R., Tated R., Nehete R (2024), "Numerical investigation of pull in control of rectangular AA1050 rolling ingot through design of convex mould during direct chill casting process", Engineering Research Express, 6(1), 1–15
6. Fegade R., Tated R., Nehete R (2024), "Experimental and Numerical Investigation of Effect of Melter Temperature and Casting Speed on Pull-In (Concavity) of AA1050 Ingot During Direct Chill Casting", Journal of The Institution of Engineers (India): Series C, 105, 69–79
7. Bledzki, A.K., & Gassan, J. (1999). "Composites reinforced with cellulose-based fibers." Progress in Polymer Science, 24(2), 221–274.
8. ASTM D3039 – 08. (2008). "Standard Test Method for Tensile Properties of Polymer Matrix Composite Materials."
9. Fegade R., Tated R., Nehete R (2022), "Numerical Analysis to Investigate the Effect of Solidification Parameters on the Pull-In Effect of Continuous Casting", Applications of Computation in Mechanical Engineering, 313–325
10. Kumar S, Singh R. Surface properties of OHNS die steel after EDM. Int J Adv Manuf Technol. 2010;50:625–633.
11. Mishra BP. Optimization of WEDM parameters using GRA. J Mech Eng. 2017;45(3):205–212.
12. Fegade R., Tated R., Nehete R.(2019), "Improving the Aluminium Rolling Ingot Recovery using TQM Technique", International Journal of Innovative Technology and Exploring Engineering (IJITEE), 8(12), 282–289.
13. Ritesh Fegade, et al, (2025) "Innovative Magnetic Coupling for Enhanced Safety in Grinding Machines", Journal of Mines, Metals and Fuels,73(3)
14. Fegade R., Tated R., Nehete R (2024), "Numerical investigation of pull in control of rectangular AA1050 rolling ingot through design of convex mould during direct chill casting process", Engineering Research Express, 6(1), 1–15
15. M. Đ. Gökler and A. M. Ozanözgü, Experimental investigation of effects of cutting parameters on surface roughness in the WEDM process, International Journal of Machine Tools & Manufacture, 40 (2000) 1831–1848.
16. Gauri SK, Chakraborty S (2010);A study on the performance of some multi-response optimisation methods for WEDM processes. Int J Adv.ManufTechnolgy 49(1–4):155–166
17. Fegade R., Tated R., Nehete R (2024), "Experimental and Numerical Investigation of Effect of Melter Temperature and Casting Speed on Pull-In (Concavity) of AA1050 Ingot During Direct Chill Casting", Journal of The Institution of Engineers (India): Series C, 105, 69–79
18. Fegade R., Tated R., Nehete R (2022), "Numerical Analysis to Investigate the Effect of Solidification Parameters on the Pull-In Effect of Continuous Casting", Applications of Computation in Mechanical Engineering, 313–325
19. Fegade R., Tated R., Nehete R.(2019), "Improving the Aluminium Rolling Ingot Recovery using TQM Technique", International Journal of Innovative Technology and Exploring Engineering (IJITEE), 8(12), 282–289.
20. Kung KY, Chiang KT (2008);Modeling and analysis of machinability evaluation in the wire electrical discharge machining (WEDM) process of aluminum oxide-based ceramic. J Mater Manufact Proc 23:241–250.
21. Khanra, A.K, Sarkar, B.R, Bhattacharya, B. (2007), "Performance of ZrB2-Cu Composite as
22. an EDM Electrode", Journal of Material Processing Technology. Vol. 183, No. 1, pp. 122–126.