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RESEARCH ARTICLE OPEN ACCESS

Optimization of Wire Cutting EDM Process Parameters for High Carbon-Chromium Steel Using Taguchi Based Grey Relational Analysis – An Overview

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ABSTRACT
Electrical Discharge Machining [EDM] is used to beat the difficulties for delivering mathematically complex shape or hard material parts by ordinary machining measure. In this current examination, the info boundaries, for example, release current [A], Pulse On-Time [B] and Pulse Off Time [C] are advanced for accomplishing ideal Material Removal Rate [MRR], decreased surface unpleasantness and Tool Wear Rate [TWR] for High carbon – chromium steel. Taguchi strategy and Gray connection investigation is applied to plan and advance the above said various execution attributes. The investigation uncovered that release current is the most powerful boundary that influences the surface completion and Material evacuation rate.
KEYWORDS: Electrical Discharge Machining, High carbon chromium steel, Taguchi's Design of Experiments, Grey Relational Analysis.

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I. INTRODUCTION

EDM is an offbeat machining measure that has been utilized to make multifaceted profiles on any electrically conductive material and independent of material's hardness and durability. The machining is cultivated by achieving nonstop discrete releases in the middle of terminal wire device (cathode) and a work piece (anode), which is segregated by a mode of dielectric liquid. The schematic of Electrical Discharge Machine is appeared. This cycle use electrothermal component for material expulsion from work piece. Potential distinction is applied among cathode and work piece, little hole is kept up between work piece and anode as a result that sparkle is produced between them. Flash energy builds temperature of wok piece over its softening point in view of that dissolving and vanishing of work piece happens. All the while, little flotsam and jetsam produced because of material expulsion from work piece is flushed away with assistance of electrolytic arrangement. Electric release machining measure is by and large utilized for cutting perplexing shapes from difficult work piece material, cutting those shapes is preposterous by regular machining measure. This is non -contact kind of machining measures in light of that less apparatus power is produced during machining measure, because of this explanation less Leftover burdens in work pieces are created. Primary restriction of electric release machining measure is work piece should be conductive.

II. PROPOSED METHODOLOGY

Taguchi methods

The Taguchi technique for quality control is a way to deal with designing that underscores the parts of innovative work, item plan and improvement in lessening the event of deformities and disappointments in made merchandise. This strategy, created by Japanese designer and analyst Genichi Taguchi, believes configuration to be a higher priority than the assembling interaction in quality control, expecting to kill changes underway before they can happen. Two significant apparatuses utilized in the Taguchi technique: -

1. Orthogonal array
2. Signal to noise ratio

Grey relational analysis

GRA is a significant piece of dark framework hypothesis spearheaded by Professor Deng in 1982[citation needed]. A dim framework implies that a framework wherein a piece of data is known, and some portion of data is obscure. With this definition, data amount and quality structure a continuum from an absolute absence of data to finish data – from dark through dim to white. Since vulnerability consistently exists, one is in every case some place in the center, somewhere close to the boundaries, some place in the ill-defined situation. Dim examination at that point goes to a reasonable arrangement of articulations about framework solutions[specify]. At one extraordinary, no arrangement can be characterized for a framework with no data. At the other outrageous, a framework with wonderful data has an interesting arrangement. In the center, dark frameworks will give an assortment of accessible arrangements. Dim investigation does not endeavor to locate the best arrangement, yet gives strategies to deciding a decent arrangement, a suitable answer for true issues. At first, the dim technique was adjusted to successfully examine air contamination and along these lines used to explore the nonlinear various dimensional model of the financial exercises' effect on the city air pollution. It has additionally been utilized to consider the exploration yield and development of countries.

III. LITERATURE REVIEW

Amite sh Goswami et al. [18] (2017) discussed in their paper that MRR (52.31%) and SR (74.69%), WWR is mainly affected by wire offset parameter. They used the process version of WEDM. The workpiece and electrode such Nimonic-80A & Brass Wire 0.25 mm. The Optimization Technique are Taguchi L27 Orthogonal Array and GRA. The input variables are Ton, Toff, Ip, WO. Cp and the output variables are MRR, Ra, WWR. Finally, they concluded that Ton is the major influencing factor for MRR (52.31%) and SR (74.69%), WWR is mainly affected by wire offset parameter.

Ashis h Goyal et al. [19] (2017) discussed in their paper that for cryogenic treated tool Current and pulse on time are the main influencing parameters. They used the process version of WEDM. The workpiece and electrode such as Inconel-625 & Zn. coated brass wire and Cry. treated Br. wire 0.25 mm. The Optimization Technique are Taguchi L18 Orthogonal Array. The input variables are Tool electrode, Ip,Ton, Toff, WF. and the output variables is MRR, Ra. Finally, they concluded that Cryogenic treated tool gives best result for MRR and Surface Roughness. For cryogenic treated tool Current and pulse on time are the main influencing parameters.

J. Udaya Prakash et al. [20] (2017) discussed in their paper that Gap voltage (V) is major influencing factor for MRR. They used the process version of WEDM. The workpiece and electrode such as AMC (Al-356/B4C/Fly ash) & Brass wire of ϕ 0.25 mm. The Optimization Technique are Taguchi L27 Orthogonal Array. The input variables are Ton, Toff, V, WF, % Reinforcement. and the output variables is MRR. Finally, they concluded that Gap voltage (V) is major influencing factor for MRR.

Ashis h Goyal et al. [21] (2017) discussed in their paper that Good surface quality. They used the process version of WEDM. The workpiece and electrode such as NA- 80A & Cryo. treated brass wire of ϕ 0.25 mm. The Optimization Technique are Taguchi L27 Orthogonal Array. The input variables are Ton, Toff, WF, Ip. and the output variables is MRR,Ra . Finally, they concluded that Good surface quality is obtained when machined with cryogenic treated brass wire as compared to normal brass wire by maintain machine parameter at same condition.

Pragadish et al. [22] (2016) discussed in their paper that Microstructure images damage. They used the process version of Dry EDM. The workpiece and electrode such as AISI D2 steel & Cu. electrode of ϕ 10 mm & O_2 gas. The Optimization Technique are Taguchi L27 Orthogonal Array and GRA. The input variables are Ip, Ton, V, Gas pressure and the output variables is MRR,Ra. Finally, they concluded that Microstructure images shows that Small micro cracks & less HAZ at optimal condition as compared to normal condition.

Mand eep kumar et al. [23] (2016) discussed in their paper that significant factors for MRR& Ra. They used the process version of WEDM. The workpiece and electrode such as Inconel X-750. The Optimization Technique are Taguchi L27 Orthogonal Array and GRA. The input variables are Ton, Toff, V, Ip, WF, WT and the output variables are CS, Ra. Finally, they concluded that Ton, Toff, V, Ip are significant factors for MRR& Ra.

U.A Dabade et al. [24] (2016) discussed in their paper that Result getting from this study is Pulse on time has more impact on MRR, SR, Kw. They used the process version of WEDM. The workpiece and electrode such as Inconel -718 & Zn. coated Br. wire of ϕ 0.25mm. The Optimization Technique are Taguchi L8 Orthogonal Array. The input variables are Ton, Toff, Ip, W.F, W.T, SV and the output variables are MRR, Ra, KW, D.D. Finally, they concluded that Result getting from this study is Pulse on time has more impact on MRR, SR, Kw.

Vijay Verma et al. [25] (2015) discussed in their paper that Micro cracks increases with increases in Ton value & reducing Toff value. They used the process version of EDM. The workpiece and electrode such as Ti-6Al-4V & copper electrode. The Optimization Technique are Taguchi

L9 Orthogonal Array. The input variables are Ton, Toff, Fp,V. and the output variables is MRR, TWR, Ra. Finally, they concluded that Micro cracks increases with increases in Ton value & reducing Toff value.

Mura hari Kolli et al. [26] (2015) discussed in their paper that Ip. Ra & RLT influence by the Cp & Ip. They used the process version of PMEDM. The workpiece and electrode such as Ti-6Al-4V & Cu. Elec. of ϕ 14 mm & Graphite powder. The Optimization Technique are Taguchi L9 Orthogonal Array. The input variables are Ip, Surfactant conc., Cp and the output variables MRR,Ra, TWR, RLT. Finally, they concluded that MRR & TWR influenced by the Ip. Ra & RLT influence by the Cp & Ip.

G. Ugrasen et al. [27] (2015) discussed in their paper that Ton is major influencing parameter for all response variables They used the process version of WEDM. The workpiece and electrode such as Surfactant HCHCr & Molybdenum wire of ϕ 0.18mm. The Optimization Technique are Taguchi L27 Orthogonal Array. The input variables are Ton, Toff, Ip, Bed speed and the output variables MRR, Ra. Finally, they concluded that Ton is major influencing parameter for all response variables i.e., MRR, Ra & Accuracy.

R. Bobbili et al. [28] (2015) discussed in their paper that study reveals that MRR, SR & Ip are improved with 6% error by employing grey relation analysis. They used the process version of WEDM. The workpiece and electrode such as (6063 alloy) & Zinc coated Brass wire of ϕ 0.25 mm. The Optimization Technique are Taguchi L18 Orthogonal Array and GRA. The input variables are Ton, Toff, Ip, V and the output variables MRR, SR, Ip. Finally, they concluded that This study reveals that MRR, SR & Ip are improved with 6% error by employing grey relation analysis.

V. Chengal Reddy et al. [29] (2015) discussed in their paper that After optimization MRR increased from 0.0522(gm/min) to 0.153(gm/min). Ra decreased from 3.261μm to 2.861 μm. Kw decreased from 0.365mm to 0. 257mm.They used the process version of WEDM. The workpiece and electrode such as Aluminium HE30 & Brass Wire as electrode. The Optimization Technique are Taguchi L27 Orthogonal Array and GRA. The input variables are Ton, Toff, Ip, WT, Upper flush, Lower flush. and the output variables MRR, Ra, Kw Finally, they concluded that After optimization MRR increased from 0.0522(gm/min) to 0.153(gm/min). Ra decreased from 3.261μm to 2.861 μm. Kw decreased from 0.365mm to 0.257mm.

Mitali S. Mahatre et al. [30] (2014) discussed in their paper that Cu. Elec. is better than Al. it gives max.MRR, Min. Ra & min. TWR as compared to Al electrode. They used the process version of EDM. The workpiece and electrode such as Ti-6Al-4V & Cu. & Al. electrode. The Optimization Technique are Taguchi L18 Orthogonal Array and GRA. The input variables are Ton, V, Ip, %Duty cycle, Electrode type and the output variables MRR, TWR, Ra Finally, they concluded that Cu. Elec. is better than Al. it gives max.MRR, Min. Ra & min. TWR as compared to Al electrode.

M.Y. Lin et al. [31] (2014) discussed in their paper that Electrode depletion is decreased from 129.1 to 70.6 μm & overcut decreased from 20.00 to 16.23 μm. They used the process version of EDM. The workpiece and electrode such as Ti-6Al-4V & Tungsten carbide tool of ϕ 0.2. The Optimization Technique are Taguchi L9 Orthogonal Array and GRA. Finally, they concluded that Electrode depletion is decreased from 129.1 to 70.6 μm & overcut decreased from 20.00 to 16.23 μm.

G. Talla et al. [32] (2014) discussed in their paper that in multi response optimization max MRR & min Ra is obtained at Ip of 3A, Ton of 150μs & Cp of 6g/L. They used the process version of PMEDM. The workpiece and electrode such as Al. metal matrix composite (Al- Al_2O_3) & Cu. The Optimization Technique are Taguchi L18 Orthogonal Array and GRA. Finally, they concluded that in multi response optimization max MRR & min Ra is obtained at Ip of 3A, Ton of 150μs & Cp of 6g/L.

B.Mo han et al. [33] (2014) discussed in their paper that Gray relational grade is improved by 3.4%.Tool (electrode) material parameter plays important role as compared to others parameters. They used the process version of EDM. The workpiece and electrode such as AISI 202 steel & WC, Br & Cu electrode The Optimization Technique are Taguchi L27 Orthogonal Array and GRA. Finally, they concluded that Gray relational grade is improved by 3.4%. Tool (electrode) material parameter plays important role as compared to other parameters.

Manja iah M. et al. [34] (2014) discussed in their paper that Error between predicted and experimental value for MRR & Ra. They used the process version of WEDM. The workpiece and electrode such asTi Ni Cu& Br. wire of ϕ 0.25 mm. The Optimization Technique are Taguchi L18 Orthogonal Array. Finally, they concluded that Error between predicted and experimental value for MRR & Ra are 3.22% & 5.73% respectively.

Shivk and Tilekar et al. [35] (2014) discussed in their paper that Ton has more effect on Ra of AL. and Ip has more effect on Ra of MS. On the other hand, WF and Ton has more influences on

KW of Al & MS. The workpiece and electrode such as Al. and MS & Brass Wire of ϕ 0.25 mm. The Optimization Technique are Taguchi L18 Orthogonal Array Finally, they concluded that Ton has more effect on Ra of AL. and Ip has more effect on Ra of MS. On the other hand, WF and Ton has more influences on KW of Al & MS.

Amite sh Goswami et al. [36] discussed in their paper that Ton and Toff are more significant parameters for MRR for WWR. version of WEDM is used. The Optimization Technique are Taguchi L27 Orthogonal Array and GRA. Finally, they concluded that Ton and Toff are more significant parameters for MRR For WWR (Ton x Toff, Ton X Ip) affect more. RL increases with increasing parameters Ton and Ip.

Anan d S Shivade et al. [37] discussed in their paper that For DD most affecting factors are Ip and WS. For MRR is mostly affected by current and pulse. version of WEDM is used. The Optimization Technique are Taguchi L9 Orthogonal Array and GRA. Input are Ton, Toff, IP, Wire Speed and output parameters are MRR, DD, MT. Finally, they concluded that For DD most affecting factors are Ip and WS. For MRR is mostly affected by current and pulse on time parameters value.

G. Rajyalakshami et al. [38] (2013) discussed in their paper that MRR is increased from 119.625 to 125.85 mm /min and SR is reduced from 1.68 to 1.44 μs, Spark gap reduced to 0.015 to 0.013mm version of WEDM is used. The Optimization Technique are Taguchi L9 Orthogonal Array and GRA. Finally, they concluded that For MRR is increased from 119.625 to 125.85 mm /min and SR is reduced from 1.68 to 1.44 μs, Spark gap reduced to 0.015 to 0.013mm.

J. Udaya Praskash et al. [39] (2013) discussed in their paper that V is significant factor mostly affecting MRR. V & WF are significant factors for Ra. version of WEDM is used. Ton, WF, V, %, Reinforcement are input parameters. The Optimization Technique are Taguchi L16 Orthogonal Array and GRA. Finally, they concluded that V is significant factor mostly affecting MRR. V & WF are significant factors for Ra.

M. Durairaj et al. [40] (2013) discussed in their paper that For MRR and Kerf width Pulse on time is major influencing factor. V, WF, Ton, Toff. Are input parameters and the output parametesr are Kw & Ra. The Optimization Technique

are Taguchi L16 Orthogonal Array. SS304 steel & Brass Wire of ϕ 0.25mm are the materials used. Finally, they concluded that For MRR and Kerf width Pulse on time is major influencing factor.

IV. EXPERIMENTAL WORK

Materials

High carbon-chromium: The D series

The D plan of the cold work class of equipment gets ready, which at first included sorts D2, D3, D6, and D7, contains some place in the scope of 10% and 13% chromium (which is inquisitively high). These gets ready hold their hardness up to a temperature of 425 °C (797 °F). Ordinary applications for these instruments plan consolidate fabricating passes on, fail miserably extending pass on squares, and drawing bites the dust. In light of their high chromium content, certain D-type gadget plans are routinely seen as faultless or semi-unadulterated, at any rate their utilization block is incredibly limited on account of the precipitation of the greater part of their chromium and carbon constituents as carbides.

CHEMICAL COMPOSITION

Table shows the chemical composition of high carbon chromium.

Element	Percentage
C	1.5%
Cr	11.0–13.0%
Mn	0.45%
P	0.030%
S	0.030%
V	1.0%
Mo	0.9%
Si	0.30%

MECHANICAL PROPERTIES

Table shows Mechanical Properties of High carbon Chromium.

Property	Value
Density	7.85 g/cm3
Pliers Hardness	45 HRC
Cutters Hardness	63 HRC
Medical-Grade Cutters Hardness	67-68 HRC
Tensile strength, ultimate	2400 MPa
Yield stress	1800 MPa
Elongation, break	40%
Modulus of elasticity	212 GPa

V. EXPERIMENTAL ANALYSIS

MATERIAL REMOVAL RATE:

Material removal rate (MRR) is the measure of material eliminated per time unit (as a rule each moment) when performing machining

activities like utilizing a machine or processing machine. The more material eliminated each moment, the higher the material expulsion rate. The MRR is a solitary number that empowers you to do this. It is an immediate pointer of how proficiently you are cutting, and how productive you are. MRR is the volume of material wiped out every second. The higher your cutting limits, the higher the MRR. Expressed in another manner, the MRR is comparable to the volume of development outlined as a prompt delayed consequence of the removal from the workpiece per unit of time during a cutting activity. The Material evacuation rate in a work cycle can be resolved as the significance of the cut, times the width of the cut, times the feed rate. The material evacuation rate is commonly estimated in cubic centimeters each moment (cm3/min).
The material removal rate is calculated by using formula:

MRR=

$$\frac{(\, weightbeforedrilling - weightafterdrilling\,)}{machiningtime * density} \frac{(mm^3)}{(s)}$$

Electrode wear rate:

EDM is a sort of machining of deciphering the state of the terminal to the workpiece, and the state of the anode is harmed by flashes. This harm is classified "anode wear". The proportion of the measure of machining of the workpiece and the measure of cathode wear is designated "terminal wear proportion", and it is significant on translating the state of the anode to the workpiece. Anode wear proportion changes because of "the blend of cathode and workpiece material", "the extremity of the voltage to apply", "the length of the flash, etc.The Electrode wear rate is calculated by using formula:

EWR=

$$\frac{(\text{ initial weight of tool} - \text{tool weight after machining })}{Time}$$

Surface roughness testing:

Surface harshness frequently abbreviated to unpleasantness, is a part of surface. It is measured by the deviations toward the ordinary vector of a genuine surface from its optimal structure. In the event that these deviations are huge, the surface is harsh; in the event that they are little, the surface is smooth. In surface metrology, unpleasantness is normally viewed as the high-recurrence, short-frequency segment of a deliberate surface. Nonetheless, practically speaking it is regularly important to know both the sufficiency and recurrence to guarantee that a surface is good for a reason.

GREY RELATIONAL ANALYSIS:

In GRA, information pre-handling is needed since the reach and unit in one information grouping may vary from the others. Information pre-preparing is additionally essential when the grouping dissipate range is excessively enormous, or when the headings of the objective in the arrangement are unique. Information pre-preparing is a cycle of moving the first succession to an equivalent grouping.

Step 1:

The first step in GRA is normalization. This can be done by using the following formula.
For Larger-the-better,

$$x_i^* = \frac{x_i(k) - \min x_i(k)}{\min x_i(k) - \min x_i(k)} \quad \text{----(1)}$$

For Smaller-the-better,

$$x_i^* = \frac{\max\, x_i(k) - x_i(k)}{\min x_i(k) - \min x_i(k)} \quad \text{----(2)}$$

Where, $x_i^*$and $x_i(k)$ are the succession after the information pre-preparing and Comparability grouping separately, k=1 for Responses; i=1, 2, 3, …9 for try Numbers 1 to 9.

Step 2:

The next step is to find the Grey Relational Coefficient $\varepsilon_i(k)$using the formula given below.

$$\varepsilon_i(k) = \frac{\Delta_{min} + \varepsilon\, \Delta_{max}}{\Delta_{0i}(k) + \varepsilon \Delta_{max}} \quad \text{-------(3)}$$

Where ε is recognizing or distinguishing proof coefficient (here it is taken as 0.5), Δ_{min} and Δ_{max} are the base and most extreme deviation arrangement esteems and $\Delta_{0i}(k)$ is the deviation succession esteem for the social trial. It can be found from the following formula.

$$\Delta_{0i}(k) = |\, x_0^* - x_i^*(k)|$$

Step 3:

Using the Grey Relational Coefficient values, the Grey Relational Grade (γ_i) for the experiments is obtained considering the two output responses. The formula used for this purpose is given below.

$$\gamma_i = \frac{1}{2}\,(\varepsilon_i(1) + \varepsilon_i(2)) \quad \text{----(5)}$$

Step 4:

The final step is to find the Grey relational grade for each factor at various levels by finding the mean grey relational grade for each level.

VI. CONCLUSION

From composing review related to OPTIMIZATION OF WIRE CUTTING EDM PARAMETERS FOR HIGH CARBON - CHROMIUM STEEL USING TAGUCHI BASED GRAY RELATIONAL ANALYSIS–AN OVERVIEW following insights are made. Taguchi system helps with finding ideal level of cycle limits to get ideal assessment of each response variable for instance MRR, Ra, etc autonomously. The huge favored situation of the Taguchi methodology is that it helps in the improvement of thing quality by giving results close to the mean of centered worth rather than an impetus inside verifiable showed limit. Taguchi procedure is the basic, straight Forward, and essential gadget for smoothing out. Another favored position is that improvement in effectiveness with measure length decline. The even display also helps for the decreased number of assessments drove for a particular number of cycle limits having a specific number of levels. The Principal obstruction of the Taguchi method is that results getting from Taguchi technique are simply relative. Taguchi procedure not overall demonstrates which limit incredibly affects the introduction characteristics regard. The even display doesn't analyze explicit components mix because of that this method isn't gifted to give an association between those variables. Taguchi technique is furthermore not applicable to those cycles that changes with time for instance unique cycles. The Upside of faint social procedure is that it is in like manner appropriate when given information is deficient or given data is discrete and find tangled interrelationship between various performing credits. EDM response variable, for instance, material departure rate and surface obnoxiousness are Generally influenced by assortment of heartbeat on time and current. The composing open on response factors, for instance, recast layer thickness and blaze opening is pitiful. Study on progression of wire cutting EDM measure limits using Taguchi and faint social assessment is less when stood out from other changed variations of EDM. At long last, Taguchi procedure and faint social examination makes measure generous just by defining measure limits at ideal level considering that creation rate and nature of thing additions.

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