Performance Analysis of Removal Rate of Material and Roughness of a Surface By Electric Discharge in Wirecut Machine on En-19a Material

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Abstract: (WIRE EDM) has turned into an imperative non-customary machining process as it gives a successful answer for creating segments to machine hard materials like zirconium, titanium and mind boggling shapes done by regular machining techniques. This paper surveys various reaction process like Surface roughness, Removal of Material Rate on process parameters like heartbeat onservo voltage (sv), pulse-on-time (TON), pulse-off-time (TOFF). The principle of destinations this exa mination research and assess the impact of various information parameters like (servo voltage(sv),beat-on-time, beat-off-time,) on material expulsion rate, surface harshness as reaction parameters have been considered for every Experiment. Experiments done on according to Taguchi's method amid machining of EN-19A work material which is High Carbon and High Chromium Die Steel (HC-HCR). 0.15mm Diameter of Metal wire cathodetaken as Experiments. The exa mination of difference (ANOVA ) strategy. This parametric examination (ANOVA) demonstrates the rate commitment of parameters exc lusively. Advance numerical models are produced utilizing Box-Behnken outline of trials of reaction surface procedure to streamline the procedure parameters utilizing condition of craftsmanship improvement methods for future investigations.

Keywords: W EDM, TON, TOFF, ANOVA , Taguchi method

1. Introduction

1.1 Selection of Material
The material EN-19A steels is a high carbon- high chromium steel performed as an experiment. These steels hold their hardness up to a temperature of 4500c.
Table 1. Chemical Composition Of EN-19A Steel

| Element | Content (%) |
|---------|-------------|
| C       | 1.50        |
| Mn      | 0.52        |
| Si      | 1.3         |
| Cr      | 0.22        |
| Ni      | 0.33        |
| Mo      | 0.06        |
| P       | 0.05        |

Table 2. Mechanical Properties of an EN-19A steel

| ELEMENT                  | METRIC          |
|--------------------------|-----------------|
| Yield Stress             | 470N/mm²        |
| Elongation               | 0.3             |
| Tensile Strength         | 810N/mm²        |
| Area of Reduction        | 0.45            |

Table 3. Physical Properties of EN-19

| Thermal Conductivity on material (w/m-k) | Density (Kg/m³) | Melting point (°C) |
|-----------------------------------------|-----------------|--------------------|
| 46.6                                    | 781             | 154                |

1.2 Applications of EN-19A

Dies stamping, metal cutting tools have a heavyweight and high strength founded as a typical applications. Aerospace industry, Punching dies, Spinning tools Ball and Roller Bearings

1.3 Wire Electric-Discharge Machining (WEDM)

(WEDM) selection is a one of the ordinary EDM process. It has a fundamental CNC controller, worktable, metal wire, tank of liquid. Wire cathode width 0.03-0.20 mmis ametal molybdenum, thin copper, or tungsten which transforms electrical vitality into warm vitality, is used for cutting on the materials. At 1500rpm on a wire drum the wire can be twisted and can be pivoted.
2. Literature Review

Prohaszka et al. (1996) studied the prerequisites of the materials that can be utilized as (WEDM) anodes and will prompt the change of (WEDM) execution. He talked about the material necessities for creating (WEDM) terminals for enhancing (WEDM) execution[1]. Tang et al. (1998) defined a neural system to reproduced tempering calculation as to anticipate cutting speed of (WEDM) process to improve the surface finish while machining stainless steel of SUS–(304) materials[2]. Gokler et al. (2000) investigated relative machining parameters for the (WEDM) process and surface roughness can be achievable for 2379 steel, 1040 steel, 2738 steel materials[3]. Kruth et al. (2001) of Katholieke University, Belgium examined and tentatively tried a few pieces of wires, with high elastic Centre and a few coatings. They have discovered that, while cutting with model wires, a critical ascent in exactness is acquired, particularly in corner cutting, while the cutting rate is at a similar level as business reference wire [4]. Puri et al. (2011) investigated on geometrical inaccuracy caused on various machine control parameters due to wire lag process[5]. Ramakrishnan et al. (2013) using the response developed surface methodology by a mathematical model [6].

3. Design of Experiment

3.1 Response Variables and Parameters by (WEDM) Process

Fundamental objectives of (WEDM) to get a superior soundness and with increased profitability. Nonetheless, because of countless in (WEDM), it is hard to accomplish the ideal execution of (WEDM) forms and the successful method for taking care of this issue is to build up the connection between the reactions factors of the procedure and its controllable info parameters.

Table 4: Parameters in WEDM process

| Serial. No. | Parameter by a Machining process | Level-1 | Level-2 | Level-3 |
|-------------|----------------------------------|---------|---------|---------|
| 1.          | Pulse-on-Time ( micro seconds μs) | 115     | 120     | 130     |
| 2.          | Pulse-Off-Time ( micro seconds μs) | 45      | 55      | 65      |
| 3.          | Servo Voltage (volt)             | 20      | 30      | 40      |

3.2 Steps to perform Taguchi design of the experiment

1. Recognize the principle work, symptoms, and disappointment mode.
2. Recognize the quality attributes common factors and testing conditions at different levels.
3. Recognize target capacity to improve.
4. Observe control factor levels.
5. Choose grid test of orthogonal cluster.
6. Conduct test on framework.
7. Analyze the levels of ideal information, and lastly for execution.
8. Investigate and plan the future activity. Principle work must be recognize, symptoms, and disappointment mode.

3.3 Key terms used in DOE
Investigation made on these variables have performance characteristic of direct influence on product or process as mentioned.

3.3.1 Factors

Two different types of factors:
(i) Factor of Discrete - values are known or level of status assumption here. Example: Container, Vendor, etc.
(ii) Factor of Continuous - It can be assume that any workable value for the factor Levels. Example: Temperature, Pressure, Thickness, etc.

3.3.2 Levels for the factors
This is the values or descriptions that define the condition of the factor held while performing the experiments.

3.3.3 Levels value for factors

| Sr. No. | Parameters fixed       | Set Value obtained          |
|---------|------------------------|-----------------------------|
| 1       | Wire material          | Brass (0.32 milli meters)   |
| 2       | Peak-current (A)       | 234                         |
| 3       | Pulse peak-voltage (V)| 2                           |
| 4       | Wire feed rate (m/min)| 4                           |
| 5       | Flushing Pressure (kgf/cm²)| 12                       |
| 6       | Wire Tension (kgf)    | 9                           |

4. Experimental Work Setup and Measurement
The setup for the experiment and examines at the Vinayaka wire cut at old Airport Road Hyderabad. The work is completed in wire cut electro release machine of EN-19A HC-HCR material by different parameters for the machining.

Figure 2. Sprint cut Wire Cut EDM

Figure 3. Control Cabinet
Table 5. Work Table

| Layout Design | Moving table fixed column, |
|---------------|----------------------------|
| Size of a Table | 420 x 630 x 300 mm |

Table 6. Max. Dimension for Work Piece

| Max. height of a work piece | 200 (mm) |
|----------------------------|----------|
| Max. weight of a work piece | 500 (kg) |
| traverse position of Main table (X,Y) | 250 x 400 (mm) |
| traverse position of Auxiliary table (U,V) | 60 x 80 (mm) |
| Wire electrode diameter | 0.25 (mm) [std.] 0.15, 0.20 (mm) [opt.]

Table 7. PULSE-GENERATOR

| Pulse-Generator | ELPULS-40 A DLX |
|-----------------|----------------|
| Pulse-peak voltage | 1 Step |
| CNC Controller | EMT 100W-5 |
| supply of Input power | 8.3 phase, AC, 415 V, 50 Hz |
| Load applied | 10 (kVA) |
| Avg power consumption | 6 to 7 (kVA) |

5. ANOVA ANALYSIS

5.1 Introduction

ANOVA table taken for the exanimating the values, obtained control parameters

Table 8. Control parameter

| Exp No | T-on (micro seconds) | T-off (micro seconds) | SV(V) | M.R.R (mm³/min) |
|--------|----------------------|-----------------------|-------|----------------|
| 1      | 110                  | 45                    | 20    | 0.0320         |
| 2      | 110                  | 45                    | 30    | 0.0325         |
6. OPTIMIZATION OBTAINED BY MULTI RESPONSE

6.1 Grey relational analysis obtained by multi response

**Table 9.** Graph plot for Grey relational grade

| Sr. No. | Machining process parameter       | Level-1 | Level-2 | Level 3 |
|---------|----------------------------------|---------|---------|---------|
| 1       | Pulse-On-Time (micro seconds)    | 115     | 120     | 130     |
| 2       | Pulse-Off-Time (micro seconds)   | 45      | 55      | 65      |
| 3       | Servo Voltage (volt)             | 20      | 30      | 40      |
6.2 Grey relational grade Response table

Table 10. Machining process parameter levels

| parameters by Machining | Average values of Grey relational grade for different factor level | Main effect [Max-Min] | Rank |
|-------------------------|---------------------------------------------------------------|----------------------|------|
|                         | Level-1 | Level-2 | Level-3 |                  |         |
| Pulse-On-Time, A        | 0.372461 | 0.609508 | 0.882459* | 0.509938 | 1 |
| Pulse-Off-Time, B       | 0.650298* | 0.618361 | 0.595769 | 0.054529 | 2 |
| Servo Voltage, C        | 0.591199 | 0.627601 | 0.645629* | 0.054430 | 3 |

6.3 Confirmation test

Table 11. Table for confirmation experiment

| LEVEL | A1B2C3 | A1B2C3 | A1B2C3 |
|-------|--------|--------|--------|
| Removal of Material Rate (mm/min) | _ | 0.0698 | 0.0783 |
| Roughness of a Surface (µm) | _ | 3.4925 | 3.5014 |
| Grey Relational Grade | 0.9353 | 0.9987 | _ |

ANOVA for GRG of metal wire terminal shows Toff and SV are most critical parameters and contributes with 30.9894% and 29.9966% separately, SV is inconsequential parameter and contributes 24.9449%. The blunder between Gray hypothesis forecast configuration utilizing programming and experimental esteems utilizing Gray social examination for GRG is 0.14999% which demonstrates that huge model is created.

7. RESULT

After obtaining values from 27 experimental values and output parameters like removal of material rate and roughness of a surface for EN-19A HC-HCR on wire cut EDM.

7.1 (Input Parameters V/S Output Parameters) Main Effect Plots

Figure 4. Graph of (input parameters v/s material removal rate)  

Figure 5. Graph of (input parameters v/s surface roughness)
7.2 MATHEMATICAL MODEL DEVELOPMENTS

Results obtained from the experiment of mathematical model between process parameters v/s machining outputs. Mathematical model coefficients are computed by method of multiple regressions. Study of S.P.S.S (Software Package for Statistical Solutions) Minitab 17. For the regression analysis custom made software created by the author was mostly used. Powerseries, linear, exponential are several models used in this software. High coefficient of multiple determination ($R^2$) value is taken. The relationship between response for the variable(s) and parameters by the process can be expressed as

Table 12. Box-Behnken design of experiments

| EXP.NO | Ton  | Toff | SV  | MRR   | SR   |
|--------|------|------|-----|-------|------|
| 1      | 110  | 55   | 20  | 0.0339| 3.1970|
| 2      | 130  | 55   | 40  | 0.0668| 3.4692|
| 3      | 110  | 65   | 30  | 0.0338| 3.0250|
| 4      | 120  | 45   | 40  | 0.0669| 3.3808|
| 5      | 120  | 45   | 20  | 0.0540| 3.575 |
| 6      | 120  | 65   | 20  | 0.0472| 3.2907|
| 7      | 120  | 55   | 30  | 0.0475| 3.2907|
| 8      | 130  | 65   | 30  | 0.0670| 3.4890|
| 9      | 130  | 55   | 20  | 0.0618| 3.4578|
| 10     | 120  | 55   | 30  | 0.0475| 3.2907|
| 11     | 120  | 55   | 30  | 0.0475| 3.2907|
| 12     | 120  | 65   | 40  | 0.0535| 3.3496|
| 13     | 110  | 45   | 30  | 0.0365| 3.1919|
| 14     | 110  | 55   | 40  | 0.0325| 3.0145|
| 15     | 130  | 45   | 30  | 0.0683| 3.4416|

8. Conclusion

From exhibited work, tests been completed for expulsion material rate and unpleasantness of a surface with factors as heartbeat on time, beat off time and servo voltage. From all factors 27 explanation values are taken to increase the parametric examination.

At last, it can be done:

The (ANOVA) founded to know the rate of information on yield parameters. (ANOVA) examinerate commitment of heartbeat-on-time is 87.2%, beat-off -time is 1.81% and servo voltage (sv)is 1.81% for material evacuation rate, which demonstrates that the impact of Pulse off time is less contrast with different parameters. The rate commitment of Pulse-on-time is 74.2%, Pulse-off-time is 1.01% and Servo voltage (sv) is 15.9% for Roughness of the Surface which demonstrates that the impact of Pulse off time is less contrast with different parameters. The blunder and rate commitment of collaboration terms found in (ANOVA) investigation is 9.18% for material expulsion rate and 8.89% for surface unpleasantness. Grey social investigation is done to discover ideal parameter levels. After examination, it is found that levels of ideal parameter like beat-on-time at level 1 (110 micro seconds), beat-off-time at level 2 (55 micro seconds), servo voltage (sv) at level 3 (40 volts). The ideal parameters of material evacuation rate of 0.0698 mm3/min, surface unpleasantness of 3.4925 μm. Process parameters don't have some little impact
for each reaction. Noteworthy parameters and its rate commitment changes according to the conduct of the parameter with target reaction.

9. Future Scope

Responses like Kerf width, circularity, roundness, cylindricity and machining cost are to be considered. The scientific model created on WEDM with various work piece and anode materials.

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