INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

ISSN: 2454-132X
Impact factor: 4.295
(Volume 4, Issue 1)
Available online at www.ijariit.com

Advancement of Process Parameters in Ultrasonic Machining of Tungsten Carbide Using Gray Taguchi

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ABSTRACT

The principle target of this paper is to contemplate the impact of working parameters of ultrasonic machining (USM) of tungsten carbide (WC) on the machining qualities like MRR and SR. The viability of the ultrasonic machining process with tungsten carbide is assessed as far as the material evacuation rate and the surface complete nature of the work piece created. Tungsten carbide as a super hard and high wear-safe material has been utilized broadly in enterprises. Dark social examinations are connected to decide the reasonable determination of machining parameters s. The Gray hypothesis can give an answer of a framework in which the model is uncertain or the data is inadequate. In addition, it gives a proficient answer for the vulnerability, multi-input and discrete information issue. As indicated by the Taguchi quality outline idea, a L9 orthogonal array. In this investigation, the impact of different information parameters; Abrasive size, Amplitude of vibration, recurrence of vibration viz., metal expulsion rate (MRR), Surface Roughness (SR) are examined. Dim social examination and investigation of difference (ANOVA) have been performed to upgrade the levels of info parameters.

Keywords: ***WC, L9 Orthogonal Array, MRR, SR.***

1. INTRODUCTION

Ultrasonic machining (USM) is a non-customary mechanical material evacuation process in which material is expelled by tedious effect of rough particles conveyed in fluid medium on the work surface, by a formed device, vibrating at ultrasonic recurrence. The use of ultrasonic vitality for machining of designing materials was first revealed by Wood and Loomis in 1927[1, 3]. Be that as it may, American designer Lewis Balamuth concocted the USM procedure in 1945. USM has been differently named as ultrasonic boring; ultrasonic cutting; ultrasonic dimensional machining; ultrasonic grating machining and slurry machining [2]. From 1950s it has been generally known as ultrasonic effect pounding or USM. In ultrasonic machining process, the converter changes electrical vitality into high recurrence mechanical vibrations. The procedure parameters of USM incorporates the static weight, vibration plentifulness, vibration recurrence, rotational speed of hardware for turning USM (RUM), precious stone coarseness fixation, Coarseness size, precious stone and bond write, slurry focus and coolant and so forth. Research takes a shot at the region of ultrasonic machining to make it more effective material expulsion forms for cutting edge materials have been requested to satisfy the need of present day producing enterprises. Albeit great number of research exercises have just been done on ultrasonic machining process, an examination in ideal determination of different overwhelming procedure parameters are as yet required for the effective adoptability of the ultrasonic machining process in satisfying the material machining needs of the cutting edge producing enterprises.

2. METHODOLOGY

2.1 GREY RELATION ANALYSIS

Dim social examination was proposed by Deng in 1989 as referred to in [7] is generally utilized for measuring the level of connection between groupings by dark social review. Dim social investigation is connected by a few specialists to enhance control parameters having multi-reactions through dim social review [8]. The utilization of Taguchi strategy with dim social investigation to upgrade the face processing operations with numerous execution attributes.

MRR is the prevailing reaction in USM which chooses the machinability of the material under thought. For the "bigger the-better "characteristic like MRR, the first arrangement can be standardized as takes after:

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

The TWR is additionally critical measures of EDM execution. The determination of ideal process parameters for EDM of tungsten carbide (WC) at the formative stage and their consequences for TWR presently can't seem to be elucidated. To get ideal cutting execution, the "littler the-better" quality trademark has been utilized for limiting the TWR. At the point when the "littler the-better" is a normal for the first grouping, at that point the first arrangement ought to be standardized.

Power Rating	Static Load	Slurry Concentration	Size of Abrasive
20	200	30	10
20	300	35	15
20	400	40	20
30	200	35	20
30	300	40	10
30	400	30	15
40	200	40	15
40	300	30	20
40	400	35	10

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

After data pre-processing is carried out, a grey relational coefficient can be calculated with the pre-processed sequence. It expresses the relationship between the ideal and actual normalized experimental results. The equation for Grey Relation Grade is as follows:

$$\xi_i(k) = \frac{\Delta_{min} + \zeta\Delta_{max}}{\Delta_{oi}(k) + \zeta\Delta_{max}} \quad (3)$$

3. EXPERIMENTAL DETAILS AND RESULTS

For the experiments the parameters selected in USM are power rating, static load, slurry concentration and abrasive grain size. The power rating ranges from 20 to 40 percent, Static load taken from 200 to 400 grams, Slurry concentration is ranges from 30 to 40 % and the Abrasive size was taken as 10, 15 and 20 microns.

Table 1: Parameters and Levels

Parameters	Level1	Level 2	Level 3
Power Rating (%)	20	30	40
Static Load(g)	200	300	400
Slurry Concentration (%)	30	35	40
Abrasive size(microns)	10	15	20

After selecting the no of parameters, the base experiments are identified using design of experiments (Taguchi) and L9 orthogonal array is selected based on four parameters and three levels.

Table 2: Design of Experiments based on L9 orthogonal array

L9 orthogonal array consisting of 9 sets of coded conditions and the experimental results for the responses of Material removal rate and Tool wear rate.

Table3 : L9 Orthogonal Array Design of Experiments

Power Rating	Static Load	Slurry Concentration	Size of Abrasive	MRR	TWR
20	200	30	10	0.854	0.193
20	300	35	15	1.034	0.302
20	400	40	20	1.334	0.285
30	200	35	20	0.518	0.267
30	300	40	10	1.684	0.268
30	400	30	15	0.895	0.243
40	200	40	15	0.989	0.241
40	300	30	20	1.331	0.288
40	400	35	10	1.652	0.244

S/N RATIO

S/N ratio is the most significant and useful parameter in taking into account of target and variation in comparing two sets of samples, when compared comparing the mean alone. Taguchi method of DoE, uses S/N ratio in ANNOVA calculations. In an experiment if one observes for a given Quality characteristic say "Nominal is Better" or "Bigger is Better" S/N values as negative, what is the interpretation.

Table 4 : Signal to Noise Ratios for the Response Variables

PSNRA/MRR	PSNRA/TWR
-1.37084	14.28885
0.290411	10.39986
2.503117	10.9031
-5.7134	11.46977
4.526842	11.4373
-0.96354	12.28787
-0.09607	12.35966
2.483561	10.81215
4.360201	12.2522

Based on Grey relation the normalisation of response variables are displayed in the table.

Table 5 : Grey Relational Generation of Each Response Variable

S NO	MRR normalized	TWR normalized
1	-0.444253859	7.403669725
2	-0.444253859	16.57798165
3	-0.444253859	25.75229358
4	-0.444253859	34.9266055
5	-0.444253859	44.10091743
6	-0.444253859	53.27522936
7	-0.444253859	62.44954128
8	-0.444253859	71.62385321
9	-0.444253859	80.79816514

Grey relational coefficient can be calculated with the pre-processed sequence. It expresses the relationship between the ideal and actual normalized experimental results.

Table 6 : **Grey Relational Coefficient for Each Output Parameter (Ψ=0.5)**

S NO	GRC of MRR	GRC of TWR
1	0.4126	0.33333
2	0.47283	1
3	0.62487	0.76224
4	0.33333	0.60894
5	1	0.61582
6	0.42493	0.48018
7	0.45618	0.47186
8	0.62286	0.79562
9	0.94797	0.48444

After obtaining the grey relational coefficient, the grey relational grade is computed by averaging the grey relational coefficient corresponding to each performance characteristic. The overall evaluation of the multiple performance characteristics is based on the grey relational grade, that is:

$$\gamma_i = \frac{1}{n}\sum_{k=1}^{n}\xi_i(k)$$

Where ¥ $_i$ the grey relational grade for the i_{th} experiment and n is is the number of performance characteristics. Table 7 shows the grey relational grade for each experiment using L_9. The higher grey relational grade represents that the corresponding experimental result is closer to the ideally normalized value. Experiment 5 has the best multiple performance characteristics among nine experiments because it has the highest grey relational grade. It can be seen that in the present study, the optimization of t h e complicated multiple performance characteristics of USM of WC has been converted into optimization of a grey relational grade.

Table 7: **Summary of Grey Relational Grades and Their Ranks**

Experiment No	**Overall Grey Relational Grade**	**Rank**
1	0.37297	9
2	0.73642	2
3	0.69355	5
4	0.47114	6
5	0.80791	1
6	0.45255	8
7	0.46402	7
8	0.70924	4
9	0.71621	3

As the experimental design is orthogonal, it is then possible to separate out the effect of each machining parameter on the grey relational grade at different levels

The ranking of the process parameters is mentioned in the table.

Table 8. Response table for the Grey Relational Grades

Level	Power Rating	Static Load	Slurry Concentration	Size of Abrasive
Level 1	0.5920	0.6100	0.4317	0.5473
Level 2	0.5380	0.5020	0.5789	0.6583
Level 3	0.6080	0.6260	0.8210	0.5323
Delta	0.0700	0.1240	0.3719	0.1260
Rank	2	1	4	3

4. CONFIRMATION TEST

The affirmation test for the ideal parameters with its levels was led to assess quality attributes for AJM of Glass. From the dark social investigation demonstrates the most astounding GRG showing the underlying procedure parameter set of (A2 B2 C3 D1) for the best numerous execution qualities among the nine tests.

The ideal dark social review (GRGopt) is anticipated by utilizing the accompanying condition:

The optimal grey relational grade (GRG_{opt}) is predicted by using the following equation:

$$GRG_{opt} = GRG_{mean} + \sum_{i=1}^{n}(GRG_i - GRG_{mean})$$

Where GRG_{mean} is the average of Grey relational grade, GRG_i is the average of grey relational analysis at optimum level and n is the significantly affecting process parameters. The predicted value of optimal grey relational grade is expressed by taking n = 4 since there are four significant parameters.

The predicted value of optimal Grey Relational Grade is calculated as:

$$GRG_{opt} = 0.57933+(0.608-0.5793)+(0.626-0.5793)+(0.6583-0.5793)$$

$$= 0.824$$

5. RESULTS OF CONFIRMATORY TEST OF GRG

Optimal Process Parameters	Predicted Value	Experimental Value
Level	A2 B2 C3 D1	A2 B2 C3 D1
MRR (gm/sec)	7	1.684
TWR	3.1	0.248
GRG	0.824	0.807

6. CONCLUSIONS

The GRA in view of the Taguchi strategy's reaction table has been proposed as a method for concentrate the advancement of USM process parameters for WC. The ideal machining parameters have been dictated by the dark social review for multi performance attributes that is MRR, TWR. Nine test runs in light of OA's have been performed. The accompanying conclusions can be drawn from this investigation.

It is recognized that the execution qualities of the EDM procedure, for example, MRR, TWR are enhanced together by utilizing the strategy proposed by this investigation. The viability of this approach has been effectively settled by approval explore.

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