OPTIMIZATION OF PROCESS PARAMETERS OF ULTRASONIC MACHINING OF TITANIUM

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Abstract: **Ultrasonic Machining (USM), as a non-traditional machining system, has been giving essential help with the machining of hard and fragile materials, whether electrically leading or non-directing. In spite of the fact that the material removal rate of the process is less, USM is better than most of other non-traditional machining strategies. This is on account of the procedure is free of warm or electrical properties of workpiece and does not thermally harm or present lingering stresses in the workpiece. The goal of the present work was to improve the process parameters like grain size, slurry fixation, power rating for acquiring most extreme Material Removal Rate utilizing Genetic Algorithms. The Taguchi Method was utilized to arrange the trials and consequent examination. Tests for process parameters on the nature of the gap bored in earthenware tiles as workpiece by Ultrasonic Drilling. The parameters taken for this examination and optimization are: Size of Abrasive Grains, Concentration of Abrasive Slurry, Power Rating of Machine and thickness of work Material. A three-level orthogonal cluster table is utilized to decide the sign to-clamor (S/N) proportions taking into account Taguchi's configuration of trials. Besides, examination of difference (ANOVA) has been performed to think about the relative criticalness of the diverse variables on cutting power and MRR of zirconia artistic. At long last, check tests were done to look at the anticipated estimations of the yields with their test values keeping in mind the end goal to affirm the adequacy of the Taguchi Optimization.**

Keywords – **Ultrasonic machining, process parameters, Taguchi Technique, ANOVA**

I. INTRODUCTION

Titanium is a synthetic component with image Ti and nuclear number 22. It is a glistening metal with a silver shading, low thickness and high quality. It is exceptionally impervious to erosion in ocean water, water regna and chlorine. The component happens inside of various mineral stores, mainly rutile and ilmenite, which are generally circulated in the Earth's hull and lithosphere, and it is found in every single living thing, rocks, water bodies, and soils[3]. The metal is removed from its important mineral metals by means of the Kroll process[4] or the Hunter process. Its most basic compound, titanium dioxide, is a famous photocatalyst and is utilized as a part of the assembling of white pigments[5]. Other mixes incorporate titanium tetrachloride ($TiCl_4$), a segment of smoke screens and impetuses; and titanium trichloride ($TiCl_3$), which is utilized as an impetus as a part of the creation of polypropylene.

Ultrasonic machining [1] is a machining operation in which a vibrating device swaying at ultrasonic frequencies is utilized to expel material from the workpiece, supported by a rough slurry that streams openly between the workpiece and the tool[2]. It contrasts from most other machining operations in light of the fact that almost no warmth is produced [2]. The apparatus never contacts the workpiece and therefore the crushing weight is once in a while more than 2 pounds [1] which makes this operation ideal for machining amazingly hard and weak materials, for example, glass, quartz, sapphire, ferrite, aluminum oxide, silicon, silicon carbide, silicon nitride, ruby, precious stone, fiber optics–and earthenware production.

The device that does the cutting is made of a harder material than the workpiece. Normally utilized device materials are nickel and delicate steels [3]. As the device vibrates, it pushes down the grating slurry, a fluid containing rough grains, until the grains sway the work piece. On account of the fragility of the workpiece, under the effect of the grating particles its surface rubs, while the gentler device material just misshapes marginally.

II. METHODOLOGY

Taguchi's technique for test plan gives a basic, effective and deliberate way to deal with and decide ideal machining parameters. Taguchi has suggested orthogonal clusters (OA) for the outlining of examinations. In taguchi technique, the consequences of trials are dissected to accomplish one or a greater amount of the goals as to set up the best or the ideal condition for an item or procedure. Investigation of fluctuation (ANOVA) is the measurable treatment connected to the aftereffects of the examinations in deciding the percent commitment of every parameter against an expressed level of certainty. The investigation of ANOVA table for a given examination figures out which of the parameters need control and which don't. Taguchi recommended two unique courses to do the complete examination. In the first place, the standard methodology, where the aftereffects of a solitary run or the normal of dull runs are prepared through fundamental impact and investigation of change. The second approach, which taguchi emphatically suggests for numerous runs, is to utilize sign to-clamor (S/N) proportion for the same strides in the examination. The S/N proportion is a simultaneous quality metric connected to the misfortune capacity. Outline of test (DOE) techniques results in a proficient trial calendar and create a factual investigation to decide effortlessly as to which parameters have the most huge consequences for the last results. The utilization of sign to-clamor (S/N) proportion in framework examination gives a quantitative worth to reaction variety correlation. The prerequisite to test numerous variables implies that a full factorial trial plan that depicts every conceivable condition would bring about countless. There are a few S/N proportions accessible relying upon the sorts of qualities; lower is better (LB), ostensible is best (NB), and higher is better (HB).

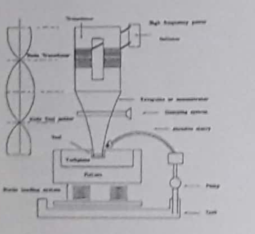

Fig 1: The setup of Ultrasonic Machining

Lower-the-better type problem

$$\eta = -10\log_{10}\left(1/n\sum_{i=1}^{n} y_i^2\right) \quad (1)$$

where (S/N) is the inspection index, defined as the signal-to-noise ratio (unit:db), n is the number of repetitions for each trial, independent of the values assigned to noise factors, and y_i is the value of the response obtained in the i^{th} repetition of the trial.

Higher-the-better type problem

In this type of problem, the quality characteristic is again continuous and non-negative and it is to be made as large as possible. There is no adjustment factor to be used in this case as well and one is interested in maximizing the objective function expressed as:

$$\eta = -10\log_{10}\left\{\frac{1}{n}\sum_{1}^{n}\frac{1}{y_i^2}\right\} \quad (2)$$

Nominal-the-best type problem

In the nominal-the-best type problem, the quality characteristic is continuous and non-negative, but its target value is non zero and **assumes** some finite value. For these types of problems, if the mean becomes zero the variance also tends to become zero. A scaling factor can be used as an adjustment factor to shift the mean closer to the target for such type of problems. The objective function that is to be maximized can be expressed as:

$$\eta = 10\log_{10}\left(\mu^2/\sigma^2\right) \quad (3)$$

$$\mu = \frac{1}{n}\sum_{1}^{n} y_i^2 \quad (4)$$

$$\sigma = \frac{1}{(n-1)\sum_{1}^{n}(y_i-\mu)^2} \quad (5)$$

The values of SS', DOF, MS, F and P as shown in ANOVA tables are calculated using MINITAB14.0 Software.

III. RESULTS & DISCUSSIONS

The parameters selected for this process are feed rate of abrasive particles and frequency of vibration. Table 1 indicates parameters at three levels and table 2 indicates surface roughness, Pnoral and Pmean1.

Table 1 Selected process parameters

Parameters	Level1	Level2	Level3
Feed rate (mm/min)	0.5	1	1.5
Frequency of vibration (kHz)	0	30	40

Response Table for Signal to Noise Ratios

Nominal is best (10×Log10(Ybar^2/s^2))

Level	FEED RATE (MM/MIN)	FREEQUENCY VIBRATION(KHZ)
1	23.08	32.11
2	24.16	20.33
3	18.96	20.79
Delta	5.21	11.78
Rank	2	1

TABLE 2 Influence of process parameters

Feed Rate (mm/Min)	Frequency of Vibration (Khz)	Surface Roughness 1	Surface Roughness 2	Pnoral	Pmean1
0.5	0	0.28	0.29	32.1072	0.285
0.5	30	0.32	0.28	18.32684	0.293333
0.5	40	0.37	0.3	18.79592	0.341667
1	0	0.35	0.35	37.71884	0.309
1	30	0.45	0.38	23.93046	0.408333
1	40	0.43	0.45	24.30737	0.471667
1.5	0	0.42	0.42	22.30696	0.435
1.5	30	0.47	0.42	18.7216	0.463333
1.5	40	0.59	0.47	19.18509	0.511667

Response Table for Means

Level	FEED RATE (MM/MIN)	FREEQUENCY VIBRATION(KHZ)
1	0.3067	0.3517
2	0.4017	0.3867
3	0.4650	0.4350
Delta	0.1583	0.0833
Rank	1	2

A. ANOVA (Analysis of Variance)

Examination of fluctuation (ANOVA) tests the speculation that the methods for two or more **populaces** are equivalent. ANOVAs survey the significance of one or more components by looking at the reaction variable means at the distinctive element levels. The invalid speculation expresses that all populace implies (component level means) are equivalent while the option theory expresses that no less than one is distinctive.

To perform an ANOVA, one should have a consistent reaction variable and no less than one unmitigated component with two or more levels. ANOVAs require information from roughly regularly appropriated populaces with equivalent fluctuations between element levels. Be that as it may, ANOVA strategies work entirely well regardless of the possibility that the typicality presumption has been abused, unless one or a greater amount of the disseminations are profoundly skewed or if the fluctuations are very distinctive. Changes of the first dataset might rectify these infringements. For instance, we plan a trial to survey the solidness of four test rug items. we put a specimen of every rug sort in ten homes and we measure toughness following 60 days. Since we are analyzing one element (rug sort) we utilize a restricted ANOVA.

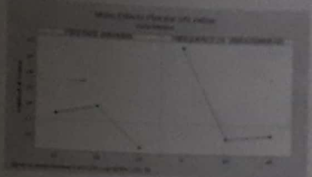

Fig 2 : Main effect plot for SN ratio of parameters

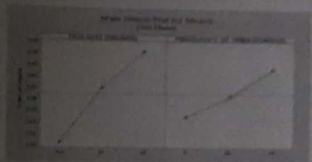

Fig 3: Main effect plot for mean of parameters

In the event that the p-worth is not exactly alpha, then infer that no less than one strength mean is distinctive. For more integrity data about the contrasts between particular means, utilize a numerous correlation strategy, for example, Tukey's. The name "investigation of change" depends on the methodology in which the technique utilizes fluctuations to figure out if the methods are distinctive. The strategy works by looking at the difference between gathering implies versus the change inside gatherings as a method for figuring out if the gatherings are all piece of one bigger populace or separate populaces with various attributes. Minitab has diverse sorts of ANOVAs to take into account extra elements, sorts of elements, and distinctive plans to suit your particular needs.

General Linear Model: SURFACE ROUGHNESS 2 versus FEED RATE (MM/MIN), FREEQUENCY OF VIBRATION Method

Factor coding (-1, 0, +1)

Factor Information

Factor	Type	Levels	Values
FEED RATE (MM/MIN)	Fixed	3	0.5, 1.0, 1.5
FREEQUENCY OF VIBRATION(KHZ)	Fixed	3	0, 30, 40

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
FEED RATE	2	0.034067	0.017033	32.97	0.003
F OV(KHZ)	2	0.005067	0.002533	4.90	0.084
Error	4	0.002067	0.000517		
Total	8	0.041200			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.0227303	94.98%	89.97%	74.61%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	0.37333	0.00758	49.27	0.000	
FEED RATE (MM/MIN)					
0.5	-0.0833	0.0107	-7.78	0.001	1.33
1.0	0.0200	0.0107	1.87	0.135	1.33
FREEQUENCY OF VIBRATION(KHZ)					
0	-0.0200	0.0107	-1.87	0.135	1.33
30	-0.0133	0.0107	-1.24	0.281	1.33

Regression Equation

SURFACE ROUGHNESS 2 = 0.37333 - 0.0833 FEED RATE (MM/MIN)_0.5
+ 0.0200 FEED RATE (MM/MIN)_1.0
+ 0.0633 FEED RATE (MM/MIN)_1.5 - 0.0200 FREEQUENCY OF VIBRATION(KHZ)_0
- 0.0133 FREEQUENCY OF VIBRATION(KHZ)_30
+ 0.0333 FREEQUENCY OF VIBRATION(KHZ)_40

It is proved that the value of R-Square is more then 90 percent, which proves that the Taguchi approach we performed is validated by using Analysis of Variance.

I. CONCLUSION

The exploration has completely exhibited Taguchi's information investigation technique which makes the determination as below: a) The orthogonal exhibit strategy presented by Taguchi is suitable in selecting the right outline with lesser number of runs.

(b) Taguchi technique gives a straight forward, methodical productive system with an orderly approach in examining the trial information.

(c) The deliberate surface unpleasantness is diminishing with the augmentation of feed rate and recurrence settings.

(d) Feed rate, which measures how quick the device goes through the work piece is the fundamental factor which affected the machining execution.

The R-Square value achieved is 94.08 which proves that the Taguchi approach is suitable for the parameters towards objective.

Fig 4 : Main effect plot of surface roughness

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