Parametric analysis of Abrasive Water jet Machine of Aluminium Material

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ABSTRACT

Abrasive water jet machine (AWJM) is a nontraditional machining process. Abrasive water jet machining is a process of removal of material by impact erosion of high pressure (1500-4000 bar), high velocity of water and entrained high velocity of grit abrasives on a work piece. It's a non-conventional machining process. At here first works on theoretical work after it make some experimental work and then analyses both results. Theoretical MRR found equal to the experimental MRR. In this paper investigation for Aluminium material is carried out using Taguchi design of experiment method. Experiments are carried out using L25 Orthogonal array by varying Material traverse speed and abrasive mass flow rate for each material respectively. Anova carried out for identifies significant parameters

Keywords - **AWJM, ANOVA, SN-Ratio, MRR.**

I. INTRODUCTION

Abrasive water jet machine (AWJM) is a nontraditional machining process. Abrasive water jet machining is a process of removal of material by impact erosion of high pressure (1500-4000 bar), high velocity of water and entrained high velocity of grit abrasives on a work piece. [3]. It's a non-conventional machining process. Abrasive water jet machining is a relatively new machining technique in that it makes use of the impact of abrasive material to erode the work piece material. It relies on the water to accelerate the abrasive material and deliver the abrasive to the work piece. In addition the water afterwards carries both the spent abrasive and the eroded material solid tool to cut the material usually by a shearing process. [1] [2].

II. EXPERIMENTAL PROCEDURE

In this investigation used three different material en8, acrylic and Aluminium and two varying parameters traverse speed and abrasive mass flow rate. Experiments are carried out using L25 Orthogonal array by varying Material traverse speed and abrasive mass flow rate for each material respectively. Anova carried out for identifies significant parameters.

2.1 Material specification: In this experiment use Aluminium (1mm thick) material.

2.3 Design of experiment based on Taguchi method:

In this investigation carried out by varying two control factors one is traverse speed and other is abrasive mass flow rate on AWJM DWJ1525-FA at A innovative international ltd, Ahmadabad. A 0.25 mm nozzle diameter, 2mm stand of distance, 2700 bar pressure and 80 mesh abrasive size silica was used is constant for every experimental work. Control factors along with their levels are listed in Table 1. Full factorial design of experiments would require a large no. of runs; Hence Taguchi based design of experiment method was implemented. In Taguchi method Orthogonal Array provides a set of well-balanced experiments, and Taguchi's signal-to-noise. (S/N) ratios, which are logarithmic functions of the desired output, serve as objective functions for optimization. It helps to learn the whole parameter space with a minimum experimental runs. Taguchi replaces the full factorial experiments with a lean, less expensive, faster partial factorial experiment.

Table 1. Control parameters and their levels

Machining Process Parameter	Level 1	Level 2	Level 3	Level 4	Level -5
Traverse Speed mm/min	50	55	60	65	70
Abrasive mass flow rate gm/min	290	310	330	350	370

2.4 Specimen detail:

L25 orthogonal array obtain based on the control factors. Total 25 nos. of experiments has been carried out and then cut a piece of 30 mm x 15 mm from 400X500 mm from Aluminum material. Water pressure 2700 bar selected as constant. Specimen after machining for each abrasive level shown in figure 1. Mass of material removal is calculated based on mass difference and theoretically based on kerf width. MRR is calculated based on it in mm^3 /min.

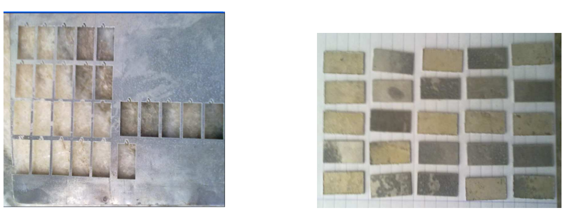

Figure.1 Specimen after Machining (Aluminium): Size –400X500mm and Thickness 1mm

III. Results and Analysis

3.1 Calculation of Signal to Noise ratio:

SN ratio can be calculated based on response requirement. Material removal rate preferred always higher is better and roughness value lower is better. According to Taguchi technique MRR calculated based on Higher is better (Eq. 1). The analysis carried out on MINITAB 15 software For EN8, ACRYLIC AND ALUMINIUM. Table 2. Shows the result with calculated Signal to Noise ratio.

$$SN\ for\ Higher\ is\ better = -10\log_{10}\left[\frac{1}{n}\sum_{i=1}^{n}\frac{1}{y_1^{2}}\right] \text{-- (Eq.1)}$$

Table 2. Taguchi Orthogonal L25 Array and result of MRR for Aluminium

SR NO	Traverse speed mm/min	Abrasive mass flow rate gm/min	MRR in mm^3*/min* Aluminium	SNRA1
1	50	290	41.47	32.3547
2	50	310	42.45	32.5576
3	50	330	43.30	32.7298
4	50	350	56.60	35.0563
5	50	370	58.06	35.2775
6	55	290	42.25	32.5165
7	55	310	42.85	32.6390
8	55	330	45.00	33.0643
9	55	350	57.32	35.1661
10	55	370	59.60	35.5049
11	60	290	43.26	32.7217
12	60	310	43.90	32.8493
13	60	330	56.96	35.1114
14	60	350	58.06	35.2775
15	60	370	60.00	35.5630
16	65	290	44.11	32.8907
17	65	310	45.00	33.0643

18	65	330	57.69	35.2220
19	65	350	59.60	35.5049
20	65	370	60.40	35.6207
21	70	290	44.77	33.0197
22	70	310	57.32	35.1661
23	70	330	59.21	35.4479
24	70	350	60.00	35.5630
25	70	370	62.06	35.8562

3.1 Analysis Of Variance (ANOVA):

Analysis of Variance (ANOVA) is a powerful analyzing tool to identify which are the most significant factors. It calculates variations about mean ANOVA results for the each response. Based on F-value (Significance factor value) important parameters can be identified. Table 3 ANOVA Table obtained by MiniTab15 software. ANOVA Table contains Degree of freedom (DF), Sum of Squares (SS), Mean squares (MS), Significant Factor ratio (F-Ratio) and Probability (P).

3.5 Result Discussion for Aluminium Material:

Table 3. ANOVA for Material Removal Rate

Source	**DF**	**Seq SS**	**Adj SS**	**Adj MS**	**F value**	**P**
Traverse Speed mm/min	4	6.376	6.376	1.5940	4.39	0.014
abrasive mass flow rate kg/min	4	19.3705	31.256	7.8140	21.50	0.000
Residual Error	16	5.815	5.815	0.3634		
Total	24	43.447				

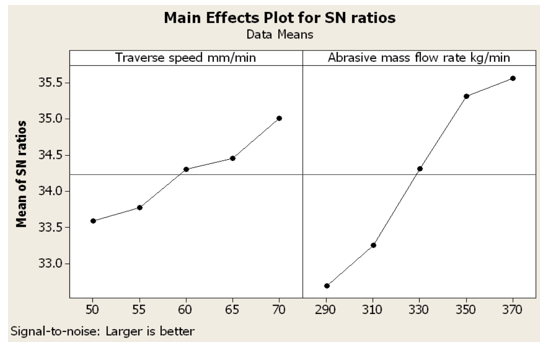

Figure 2. Plot for Mean of SN Ratio (MRR) v/s Factor for Aluminium

Figure.2 shows that MRR increases with increasing of abrasive mass flow rate and Traverse Speed. ANOVA analyses calculate F-ratio (Table 3) for abrasive mass flow rate 21.50 and for Traverse Speed 4.39. . P-value is <0.05 (α level), Hence both parameters are significant.

3.6 theoretical Material removal rates for Material:

For finding the theoretical MRR follow this equation for material removal rate for different materials.

The equation is

$$MRR = h_t \, w \, v_f \ldots\ldots\ldots\ldots\ldots \quad eq\ (2)$$

Where,

h_t = depth of penetration

w = width of the kerf

$= (w_{top} + w_{bottom}) / 2$

$\approx d_i$, the diameter of the focusing tube or nozzle or the insert

v_f = traverse speed of the AWJ or cutting speed

And for the measuring the Value of (h_t) depth of penetration by this equation is

$$h_t = \frac{\pi}{4} d_o^2 R \left(\frac{1}{1+R} \right)^2 \frac{p^{\frac{3}{2}}}{\mu_{job} d_i v_f} \sqrt{\frac{2}{q_w}}$$

………..eq(3)

Where,

- d_o = orifice diameter in mm
- d_i = insert diameter in mm
- R = mass flow rate of abrasive (m_{abr}) / mass flow rate of water (m_w)
- ρ_w = density of water
- μ_{job} = specific energy of material j/mm3
- P = pressure in bar (psi)
- v_f = traverse speed mm/min. [1]

Now with the help of this equation find the MRR at different traverse speed of 50, 55, 60, 65, 70 mm/min and abrasive mass flow rate 290, 310, 330, 350, 370 gm/min for Taguchi array L25 in Table 4.

Table 4. Taguchi Array L25 and result of MRR Aluminium

Sr no	Traverse speed in mm/min	Abrasive mass flow in gm/min	MRR in mm^3 */min* Aluminium
1	50	290	44.08
2	50	310	44.84
3	50	330	48.64
4	50	350	52.06
5	50	370	55.11
6	55	290	44.31
7	55	310	44.46
8	55	330	48.91
9	55	350	52.25
10	55	370	55.18
11	60	290	44.23
12	60	310	44.69
13	60	330	48.79
14	60	350	51.98
15	60	370	54.72
16	65	290	43.97
17	65	310	44.95
18	65	330	48.41
19	65	350	51.87
20	65	370	55.33
21	70	290	44.16
22	70	310	45.22
23	70	330	48.41
24	70	350	51.60
25	70	370	55.43

IV. CONCLUSION

This paper presents analysis of various process parameters and drawn following conclusions from the experimental study:

- MRR increase for Aluminium- 44.08 to 55.43 mm^3/ min by increasing abrasive mass flow rate (290 to 370).
- Increasing speed (50 to 70) is also increase MRR.
- Full factorial design help for analysis as no separate combination needs for confirmation test.

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