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Experimental Investigation of MRR and Surface Finish Using Abrasive Jet Machining

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Abstract:-

In this paper, different experiments are performed on Aluminum alloy 6082 by varying various parameters such as Feed, Stand off Distance, Pressure, Exit water velocity and thickness of plate to determine Material Removal rates and surface finish. Optimization is done using L12 orthogonal array by Taguchi technique to determine better parameters to obtain maximum removal rates and minimum surface roughness. The parameters considered are Thickness 6mm, 8mm, Stand off Distance 5mm, 10mm, Pressure 50000psi, 60000psi, Exit Water Velocity 140mm/min, 350mm/min and Feed 450rpm, 600rpm.

I. Introduction

In AJM, work material is removed by erosion of high velocity abrasive particles by impinging stream of abrasive particles carried by high pressure air or gas through a nozzle on the work surface.

In Abrasive Jet machining rough particles are made to impinge on work material at high speed. Jet of abrasive particles is conveyed via transporter gas or air. The high speed stream of abrasives is created by changing over weight vitality of transporter gas or air to its Dynamic vitality and thus high speed fly. Abrasive jet is directed through the nozzle in a controlled way onto work material. The high speed rough particles evacuate the material by micro cutting activity and brittle fracture of the work material.

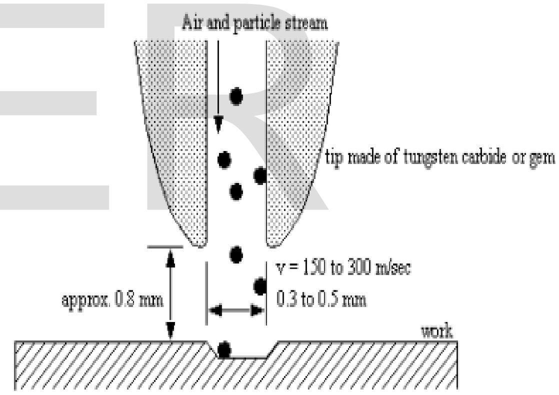

Fig.1. Principle of Abrasive Jet Machining.

II. Literature Review

In this review the experimental analysis of Abrasive jet machining is mentioned. The experimentations conducted by varied researchers by influencing the abrasive jet machining (AJM) method parameters on material removal rate, Surface integrity, kerf square measure mentioned. The parameters like SOD, Carrier gas, atmospheric pressure, kind of Abrasive, Size, compounding magnitude relation etc. are centered.

P. Jankovi´c[1], the analysis aim was connected with the stress of trade, i.e. the tip user. Having in mind that the standard machining processes don't seem to be solely insulant behind in terms of quality of cut, or maybe some requests don't seem to be able to meet, however with the appearance of composite materials weren't able to machine them, as a result of they occurred unacceptable injury (mechanical injury or delamination, fiber pull-out, burning, worn edges).Dr. A. K. Paul et al.[2] administrated the result of the carrier fluid (air) pressure on the MRR and therefore the material removal issue (MRF) are investigated through {an experiment} on an autochthonic AJM set-up developed within the laboratory. Experiments square measure conducted on ceramic ware with carbide as abrasive particles at varied atmospheric pressures. it absolutely was determined that MRR has augmented with increase in grain size and increase in nozzle diameter. The dependence of MRR on stand-off distance reveals that MRR will increase with increase in SOD at a selected pressure.

III. Experimental Methodology

Experimentation is conducted by machining Aluminum 6082 pieces by varying the process parameters considered plate thickness, Nozzle Stand off Distance (distance between nozzle and work piece), Exit water velocity, Pressure and Feed rate and their performance is measured on the material removal rate.

Work piece size

Two rectangular piece of Aluminum 6082 material with dimensions 220mm length, 150mm width and 6mm, 8mm thickness plates each are taken and machined using water jet machining by varying the process parameters Feed rate, Pressure, Water Exit Velocity and Nozzle Stand off Distance (i.e) distance between nozzle and work piece. The Abrasivetype used is garnet.

The parameters are varied as per L12 orthogonal array using Taguchi Technique.

Parameters Used for Machining

JOB NO.	Thickness (mm)	Nozzle Stand off Distance (mm)	Feed Rate (rpm)	Exit water velocity (mm/min)	Pressure (Psi)
1	6	5	450	140	50000
2	6	5	450	140	50000
3	6	5	600	350	60000
4	6	10	450	350	60000
5	6	10	600	140	60000
6	6	10	600	350	50000
7	8	5	600	350	50000

8	8	5	600	140	60000
9	8	5	450	350	60000
10	8	10	600	140	50000
11	8	10	450	350	50000
12	8	10	450	140	60000

Table. I. Process Parameters taken for machining

Material--------------Aluminum alloy 6082

Thickness ---- 6mm, 8mm

Feed Rate(Tool Speed) ---- 450rpm, 600rpm

Nozzle Stand off Distance – 5mm, 10mm

Water Jet Velocity ----- 140mm/min, & 350mm/min

Pressure ------- 50000psi, 60000psi

Sand Feed------- 300g/min

Software for design ----- Autocad

Software For CNC Coding ------Item CAD, Most 2D.

Water consumption ----200ltrs/hr.

Fig.2. Setting of work piece on the machine

Surface Roughness Results

JOB NO.	Thickness (mm)	Nozzle Stand off Distance (mm)	Feed Rate (rpm)	Exit water velocity (mm/min)	Pressure (Psi)	Surface Finish Values R_a µm
1	6	5	450	140	50000	4.822
2	6	5	450	140	50000	4.82
3	6	5	600	350	60000	4.78
4	6	10	450	350	60000	4.85
5	6	10	600	140	60000	4.67
6	6	10	600	350	50000	4.8
7	8	5	600	350	50000	4.726
8	8	5	600	140	60000	4.69
9	8	5	450	350	60000	4.88
10	8	10	600	140	50000	4.7
11	8	10	450	350	50000	4.91
12	8	10	450	140	60000	4.86

Table. II. Measured Surface Roughness values for experimental data

Calculation of material removal rates

To calculate material removal rates, the time taken for machining and the weight of the work piece are measured as per table given below.

The time taken and weight of the work piece after each machining are measured and are depicted in below table.

JOB NO.	Thickness (mm)	Nozzle Stand off Distance (mm)	Feed Rate (rpm)	Exit water velocity (mm/min)	Pressure (Psi)	Time Taken (Secs)	Weight (gms)
1	6	5	450	140	50000	26	0.5184
2	6	5	450	140	50000	24	0.5022
3	6	5	600	350	60000	23.5	0.486
4	6	10	450	350	60000	22.7	0.4698
5	6	10	600	140	60000	20.5	0.4536
6	6	10	600	350	50000	22.1	0.4374
7	8	5	600	350	50000	24.9	0.6966
8	8	5	600	140	60000	23.6	0.6804
9	8	5	450	350	60000	25.5	0.6642
10	8	10	600	140	50000	21.6	0.648
11	8	10	450	350	50000	24.5	0.6318
12	8	10	450	140	60000	22.3	0.6156

Table. III. Measured time taken for machining and weight of the components after machining

During the process of machining the high velocity jetof abrasive air mixture is bombarded into the work piece .The each particle of abrasive powderremoves material from work piece. The MRR isdefined as the ratio of the difference of weight of thework piece before and after machining to the productof machining time and density of the material.

Material removal rate MRR = $(W_b – W_a) / t * \rho$

Where

W_b = Weight of work piece before machining (Kg)

Wa = Weight of work piece after machining (Kg)

t = Machining Time (Secs)

ρ =Density of work piece (Kg/mm^3)

The MRR values calculated from the experimental data is as shown in below table.

JOB NO.	Thickness (mm)	Nozzle Stand off Distance (mm)	Feed Rate (rpm)	Exit water velocity (mm/min)	Pressure (Psi)	MRR (mm^3/sec)
1	6	5	450	140	50000	230.679
2	6	5	450	140	50000	250
3	6	5	600	350	60000	255.31
4	6	10	450	350	60000	264.317
5	6	10	600	140	60000	292.68

6	6	10	600	350	50000	271.49
7	8	5	600	350	50000	240.96
8	8	5	600	140	60000	254.237
9	8	5	450	350	60000	235.29
10	8	10	600	140	50000	277.77
11	8	10	450	350	50000	244.89
12	8	10	450	140	60000	269.05

Table – Calculated MRR values for experimental data

IV. Optimization of Machining Parameters for Higher Material Removal Rates and Lesser Surface Roughness Using Minitab Software

MRR

Options – Larger is better

Results Table

Worksheet 1 ***

↓	C1	C2	C3	C4	C5	C6	C7
	Thickness (mm)	Standoff Distance (mm)	Feed Rate (rpm)	Exit Water Velocity (mm/min)	Pressure (Psi)	MRR (mm3/sec))	SNRA2
1	6	5	450	140	50000	230.679	47.5954
2	6	5	450	140	50000	250.000	*
3	6	5	600	350	60000	255.310	48.1414
4	6	10	450	350	60000	264.317	48.4425
5	6	10	600	140	60000	292.680	49.3279
6	6	10	600	350	50000	271.490	48.6751
7	8	5	600	350	50000	240.960	47.6389
8	8	5	600	140	60000	254.237	48.1048
9	8	5	450	350	60000	235.290	47.4321
10	8	10	600	140	50000	277.770	48.8737
11	8	10	450	350	50000	244.890	47.7794
12	8	10	450	140	60000	269.050	48.5967

Table.IV. – Calculated Signal to Noise Ratios for Larger is better

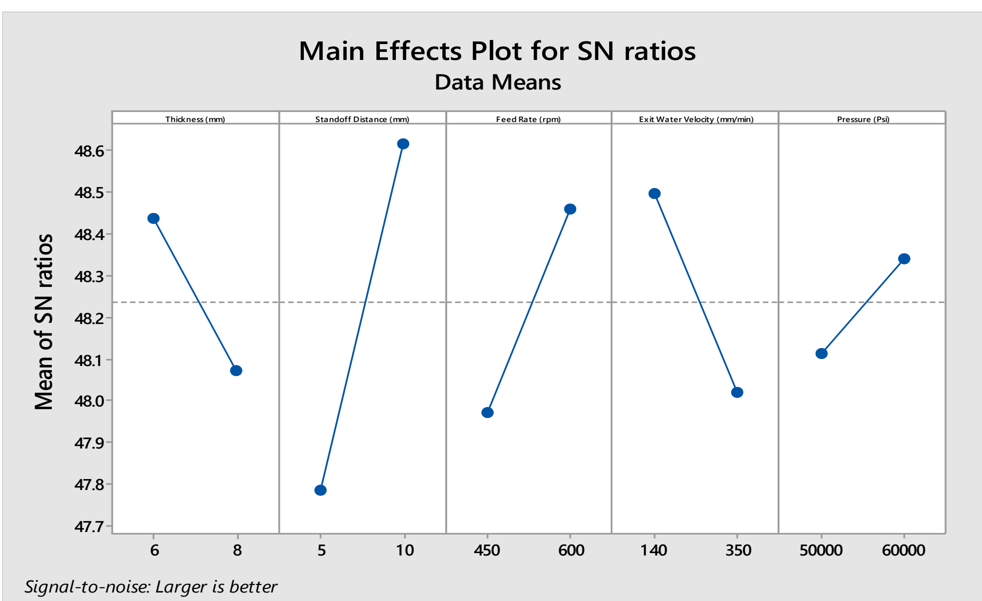

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Fig.2. Effect of machining parameters on MRR for S/N ratio for Larger is better

Thickness:- The effect of parameter Thickness on MRR is shown above figure S/N ratio. So the optimum Thicknessis 6mm.

Stand off Distance:- The effect of parameter Stand off Distance on MRR is shown above figure S/N ratio. So the optimum Stand off Distanceis 10mm.

Feed Rate:- The effect of parameter feed rate on MRR is shown above figure S/N ratio. So the optimum feed rate is 600rpm.

Water Velocity :- The effect of parameters Water Velocityon MRR is shown above figure for S/N ratio. So the optimum water velocity is140 mm/min.

Pressure :- The effect of parameters Pressureon MRR is shown above figure for S/N ratio. So the optimum Pressure is60000psi.

SURFACE ROUGHNESS

Options – Smaller is better

Results Table

↓	C1	C2	C3	C4	C5	C6	C7
	Thickness (mm)	Standoff Distance (mm)	Feed Rate (rpm)	Exit Water Velocity (mm/min)	Pressure (Psi)	Surface Roughness	SNRA3
1	6	5	450	140	50000	4.822	-13.6627
2	6	5	450	140	50000	4.820	*
3	6	5	600	350	60000	4.780	-13.5886
4	6	10	450	350	60000	4.850	-13.7148
5	6	10	600	140	60000	4.670	-13.3863
6	6	10	600	350	50000	4.800	-13.6248
7	8	5	600	350	50000	4.726	-13.4899
8	8	5	600	140	60000	4.690	-13.4235
9	8	5	450	350	60000	4.880	-13.7684
10	8	10	600	140	50000	4.700	-13.4420
11	8	10	450	350	50000	4.910	-13.8216
12	8	10	450	140	60000	4.860	-13.7327

Table. V. Calculated Signal to Noise Ratios for Smaller is better

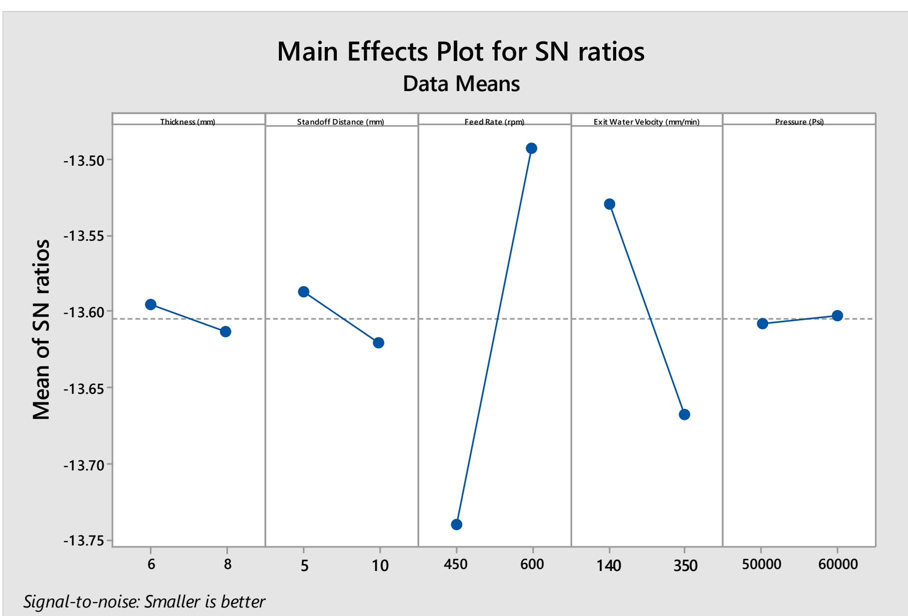

Fig.3. Effect of machining parameters on Surface Roughness for S/N ratio for Smaller is better

Thickness:- The effect of parameter Thickness on MRR is shown above figure S/N ratio. So the optimum Thicknessis 6mm.

Stand off Distance:- The effect of parameter Stand off Distance on MRR is shown above figure S/N ratio. So the optimum Stand off Distanceis 5mm.

Feed Rate:- The effect of parameter feed rate on MRR is shown above figure S/N ratio. So the optimum feed rate is 600rpm.

Water Velocity :- The effect of parameters Water Velocityon MRR is shown above figure for S/N ratio. So the optimum water velocity is140 mm/min.

Pressure :- The effect of parameters Pressureon MRR is shown above figure for S/N ratio. So the optimum Pressure is60000psi.

V. CONCLUSION

From the experimental results and the Taguchi method, the following results can be obtained:For Minimum Surface Roughness, the optimum Thicknessis 6mm, the optimum Stand off Distanceis 5mm, the optimum feed rate is 600rpm, the optimum water velocity is140 mm/min and the optimum Pressure is60000psi. For Maximum MRR, the optimum Thicknessis 6mm, the optimum Stand off Distanceis 10mm, the optimum feed rate is 600rpm, the optimum water velocity is140 mm/min and the optimum Pressure is60000psi.

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