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Analysis of Different Parameters of Abrasive Water Jet Machining

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Abstract— Abrasive water jet machine being perfect combination of water jet machine and abrasive jet machine, it uses principle of both of these machine and thus it is proven to be the most effective technology of material removal process and is now being widely used in industries as it has many advantages such as it is highly flexible, small cutting forces, no thermal distortion. This machine works with high pressure high velocity water spray and high velocity of abrasive material forced on the work piece used for cutting process. There are many process parameters with which the quality of machining on the surface differs. Some of these process parameters are traverse speed, stand of distance, abrasive flow rate, water jet pressure. Also the quality parameters which provide the quality of the cutting surface are material removal rate, surface roughness and kerf width. This paper reviews the work done so far for the parameters of Abrasive Water jet Machine.

Keywords— Abrasive Waterjet Machining, MRR, Surface Roughness, L27 Orthogonal Array, ANOVA

I. INTRODUCTION

The Abrasive Water Jet (AWJ) technique over the years is the most widely used for removal of material in industry. The Abrasive Water Jet is a versatile tool which is used to machine all the material with accuracy thus obtains place in many industries. The surface roughness of the finished product is very much important in determining the use of that component. As high velocity and high pressure water jet is required which is obtained by passing a compressed air through the nozzle to obtain high pressure forces. A high-speed water jet as described and air enter a cutting head from different entries. In the cutting head, these phases are mixed and the abrasive particles and the air are accelerated. As a result, an abrasive water jet is formed in the cutting head. The materials used as abrasive in water jet machine are garnet, aluminum oxide, silica-sand, zirconium, silicon carbide. Thus wide range of advantages possessing Abrasive Water Jet Machine thus has a great place for cutting process in the industry.

II. DETAILS EXPERIMENTAL

A. Machine Used

The Water Jet Machine used for this particular experiment was JetCut 30B-30S by Innovative International Ltd. The input parameters were Pressure (MPa), Standoff Distance (mm) and Abrasive Flow rate (g/min).

Fig 1: Abrasive Water Jet Machine

Length	3m
Width	3m
Power	7KW
Voltage	415V
Frequency	50Hz
SCCR	17A
Abrasive Particle Used	Garnet
Abrasive Particle Size	80 mesh
Pressure Pump	4000MPa
Nozzle Dia.	0.33mm
Nozzle Length	100mm
Cutting Speed	100mm/s-1000mm/s
Booster Pump	Input-3bar, Output-6bar

TABLE I: SPECIFICATIONS OF AWJ MACHINE

B. *Material and Work Piece*

- Material of the block: Aluminum
- Initial Weight – 96.161gms
- Dimension – 60mm×42mm×16mm

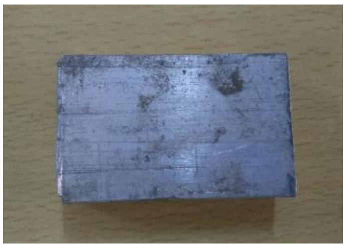

Fig 2: Aluminum block before machining

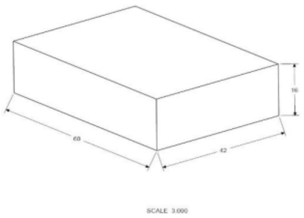

Fig 3: Dimension of the block used before machining

C. *Methodology*

A rectangular work piece has been cut into a prototype of an automotive part. The experiment is be held by Taguchi L27 Orthogonal Array method. This array consists of three control parameters and three levels. The optimization of the observed values was determined by analysis of variance (ANOVA). The Material Removal Rate was measured by the difference of initial weight of work piece and the final weight of work piece after machining to time taken through the cutting.

$$MRR = \frac{\text{Initial Weight} - \text{Final Weight}}{\text{Time taken for Cycle}}$$

LEVEL	PARAMETER		
	Jet Pressure	Standoff Distance	Abrasive Flow Rate
1	2000	3	300
2	2500	4	400
3	3000	5	500

TABLE II: FACTOR AND THEIR LEVEL FOR L27 ORTHOGONAL ARRAY

Experiment No.	Jet Pressure (MPa)	Standoff Distance (mm)	Abrasive Flow Rate (g/min)	MRR (g/s)
1	2000	3	300	0.602
2	2000	3	300	0.612
3	2000	3	300	0.602
4	2000	4	400	0.612
5	2000	4	400	0.612
6	2000	4	400	0.612
7	2000	5	500	0.602
8	2000	5	500	0.607
9	2000	5	500	0.618
10	2500	3	400	0.621
11	2500	3	400	0.621
12	2500	3	400	0.627
13	2500	4	500	0.621
14	2500	4	500	0.627
15	2500	4	500	0.621
16	2500	5	300	0.615
17	2500	5	300	0.627
18	2500	5	300	0.621
19	3000	3	500	0.624
20	3000	3	500	0.624
21	3000	3	500	0.630
22	3000	4	300	0.636
23	3000	4	300	0.630
24	3000	4	300	0.636
25	3000	5	400	0.630
26	3000	5	400	0.624
27	3000	5	400	0.636

TABLE III: L27 ORTHOGONAL ARRAY FOR MRR AND SURFACE ROUGHNESS

Fig 4: Finished Work Piece

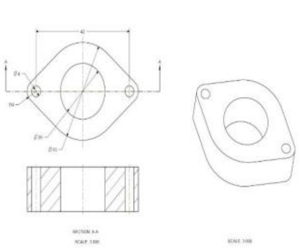

Fig 5: Dimensions of Finished Work-piece

Fig 6: Finished Work Piece with its primary block

III. RESULT AND DISCUSSION

A. *Result of ANOVA for MRR*

The effect of process parameters were investigated by using ANOVA. The table below shows the ANOVA analysis for material removal rate.

Source	Degree of Freedom	Sum of Square	Mean Variance	F-Ratio	%
Jet Pressure	2	0.002118	0.001559	129.87	0.5641
Standoff Distance	2	0.000864	0.000432	56.10	0.2202
Abrasive Flow Rate	2	0.000806	0.000403	52.33	0.2049
Error	20	0.000154	0.0000077		0.0410
Total	26	0.003754			

TABLE IV: ANOVA FOR MATERIAL REMOVAL RATE

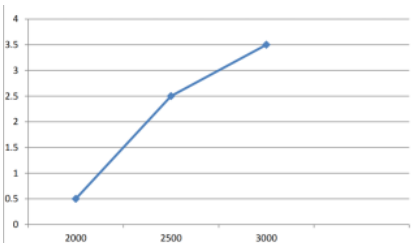

Fig: Effect of Jet Pressure on MRR

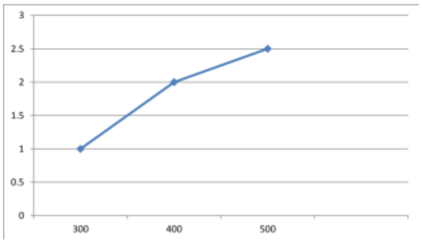

Fig: Effect of Abrasive Flow Rate on MRR

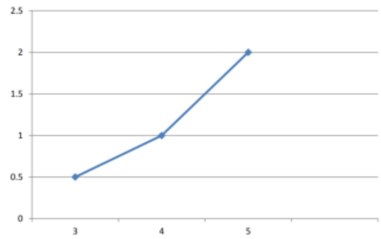

Fig 9: Effect of Standoff Distance on MRR

It was found that Abrasive Flow Rate is not a significant parameter. Control factor that is Jet Pressure and is the most significant factor and SOD has almost equal significance as that of Abrasive Flow Rate.

Fig 13: Some Damage Piece While Performing Experiment

IV. CONCLUSIONS

It is found that water pressure is most significant parameter for MRR. The percentage contribution of water pressure for MRR is 56.41% and that of Abrasive Flow Rate is 20.44% and Standoff Distance has 22.02%. This error is due to human ineffectiveness whichis about 0.4%. It was found that the standoff distance failed the test of significant at 95%confidence level therefore it was pooled out.

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