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EXPERIMENTAL INVESTIGATION OF MRR AND SURFACE FINISH USING ABRASIVE JET MACHINING OF Al 7075 ALLOY

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ABSTRACT

In this thesis, different experiments are performed on Titanium alloy 2 by varying machining parameters such as Transverse Speed, Abrasive Flow Rate and Standoff Distance (i.e) Nozzle to work piece distance to determine Material Removal rates and surface Roughness. Optimization is done using L9 orthogonal array by Taguchi technique and ANOVA method is done to determine better parameters to obtain maximum removal rates and maximum hardness.

The parameters considered are Abrasive flow rate 320g/min, 470g/min, 620g/min, Standoff Distance 1mm, 1.5mm, 2mm, and Transverse Speed 350mm/min, 500mm/min, 650mm/min Optimization of machining parameters using Taguchi Technique is done in Minitab 17. ANOVA are also done for optimization.

INTRODUCTION

This novel technology was first initiated by Franz to chop laminated paper tubes in 1968 and was first introduced as a poster system in 1983. Within the 1980s garnet of abrasive was added to the water stream and here therefore the abrasive jet machine was born. Within the early 1990s, water jet pioneer scientist Dr. John Olsen began to discover the concept of abrasive jet cutting as a practical alternative for traditional machine shops. His end goal was to develop a system that might eliminate the noise, dust and expertise demanded by abrasive jets at that point. In the last 20 years, an intensive deal of investigation and development in AJM is conducted.

PROCESS

- Fine particles (0.025mm) are accelerated in a gas stream
- The particle are directed towards the focus of machining
- As the particles impact the surface, it causes a micro fracture, and gas carries fractured particles away
- Brittle and fragile work better

MACHINIG OPERATIONS

Here in our project milling and AWJM process are involved for the better optimization. Other operations falling in to some basic machining categories like shaping, boring, broaching and sawing are used if necessary.

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In general there are many types of operations and each operation of capable of generating a required part geometry and the surface texture required. If we see in turning operation, here the cutting tool is placed with a single cutting edge and used to remove the excess material which is not necessary and the operation is carried out by a cylindrical shape on the work piece. In turning process, the initial motion is generated by rotating the work piece and later the machine feed rate is achieved by moving the cutting tool slowly in parallel direction to the work piece axis of rotation.

LITERATURE REVIEW

In this review the experimental analysis of Abrasive jet machining is discussed. The experimentations conducted by various researchers by influencing the abrasive jet machining (AJM) process parameters on material removal rate, Surface integrity, kerf are discussed. The parameters like SOD, Carrier gas, Air Pressure, Type of Abrasive, Size, Mixing Ratio etc. are focused.

P. Jankovi´c[1], the research aim was connected with the demands of industry, i.e. the end user. Having in mind that the conventional machining processes are not only lagging behind in terms of quality of cut, or even some requests are not able to meet, but with the advent of composite materials were not able to machine them, because they occurred unacceptable damage (mechanical damage or delamination, fiber pull-out, burning, frayed edges).

Dr. A. K. Paul et al.[2] carried out the effect of the carrier fluid (air) pressure on the MRR and the material removal factor (MRF) have been investigated experimentally on an indigenous AJM set-up developed in the laboratory. Experiments are conducted on Porcelain with silicon carbide as abrasive particles at various air pressures. It was observed that MRR has increased with increase in grain size and increase in nozzle diameter. The dependence of MRR on stand-off distance reveals that MRR increases with increase in SOD at a particular pressure.

Dr. M. Sreenevasa Rao [3] reviewed that Ingulli C. N. (1967) was the first to explain the effect of abrasive flow rate on material removal rate in AJM. Along with Sarkar and Pandey (1976) concluded that the standoff distance increases the MRR and penetration rate increase and on reaching an optimum value it start decreasing.

J. Wolak (1977) and K. N. Murthy (1987) investigated that after a threshold pressure, the MRR and penetration rate increase with nozzle pressure. The maximum MRR for brittle and ductile materials are obtained at different impingement angles. For ductile material impingement angle of 15-20 results in maximum MRR and for brittle material normal to surface results maximum MRR.

The parameters used for L9 orthogonal array using taguchi method are

PARAMETERS USED FOR MACHINING

	Abrasive Flow Rate (g/min)	Nozzle Standoff Distance (mm)	Transverse speed (mm/min)
LEVEL 1	320	1	350
LEVEL 2	470	1.5	500
LEVEL 3	620	2	650

Table –Parameters taken for machining

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EXPERIMENTATION PHOTOS

Fig – Setting of work piece on the machine

Fig – Piece to be machined

Fig – Machining process

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

Job No.	Abrasive Flow Rate (g/min)	Nozzle Standoff Distance (mm)	Transverse Speed (mm/min)	MRR (mm^3/sec)
1	320	1	350	613.88
2	320	1.5	500	571.49
3	320	2	650	613.36
4	470	1	500	577.30
5	470	1.5	650	642.79
6	470	2	350	604.98
7	620	1	650	671.41
8	620	1.5	350	631.67
9	620	2	500	590.33

Table – Calculated MRR values for experimental data

Measured hardness results after the machining process using taguchi method

Job No.	Abrasive Flow Rate (g/min)	Nozzle Standoff Distance (mm)	Transverse Speed (mm/min)	Hardness 1	Hardness 2	Hardness 3	Average BHN value
1	320	1	350	62.4	61.8	62.4	62.2
2	320	1.5	500	63	63.8	63.8	63.53
3	320	2	650	68.8	68.2	68.8	68.6
4	470	1	500	60.6	60.1	60.6	60.13
5	470	1.5	650	54.8	55.3	55.3	55.13
6	470	2	350	59.5	60.1	60.1	59.9
7	620	1	650	76.3	75.5	76.3	76.03
8	620	1.5	350	63	63.6	64.2	63.6
9	620	2	500	62.4	63.6	63	63

OPTIMIZATION OF MACHINING PARAMETERS FOR HIGHER HARDNESS USING MINITAB SOFTWARE

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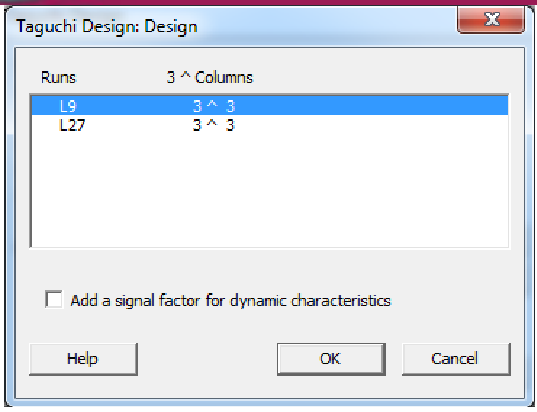

Fig – Selecting L9 (9*9)

Select Factors - Enter Factors and their respective values

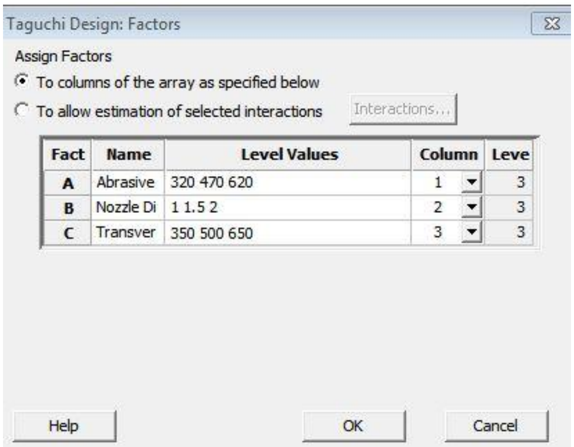

Fig – Considered parameters with their values

Results Table

Worksheet 1 ***

↓	C1	C2	C3	C4	C5	C6	C7	C8
	Abrasive Flow Rate	Nozzle Distance	Transverse speed	hardness 1	hardness 2	hardness 3	SNRA1	MEAN1
1	320	1.0	350	62.4	61.8	62.40	35.8755	62.2000
2	320	1.5	500	63.0	63.8	63.80	36.0596	63.5333
3	320	2.0	650	68.8	68.2	68.80	36.7263	68.6000
4	470	1.0	500	60.6	60.1	60.60	35.6253	60.4333
5	470	1.5	650	54.8	55.3	55.30	34.8280	55.1333
6	470	2.0	350	59.5	60.1	60.10	35.5482	59.9000
7	620	1.0	650	76.3	75.5	76.30	37.6198	76.0333
8	620	1.5	350	63.0	63.6	64.22	36.0693	63.6067
9	620	2.0	500	62.4	63.6	63.00	35.9860	63.0000

Table – Calculated Signal to Noise Ratios for Larger is better

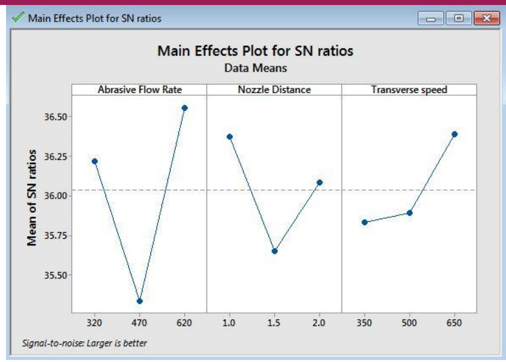

Fig - Effect of machining parameters on Hardness for S/N ratio for Larger is better

OPTIMIZATION OF MACHINING PARAMETERS FOR HIGHER MRR USING MINITAB SOFTWARE

Enter MRR values in the table

Worksheet 1 ***

↓	C1	C2	C3	C4
	Abrasive Flow Rate	Nozzle Distance	Transverse speed	MRR
1	320	1.0	350	613.88
2	320	1.5	500	571.49
3	320	2.0	650	613.36
4	470	1.0	500	577.30
5	470	1.5	650	642.79
6	470	2.0	350	604.98
7	620	1.0	650	671.41
8	620	1.5	350	631.67
9	620	2.0	500	590.33

Fig- Observed MRR values from experimentation

Results Table

Worksheet 1 ***

↓	C1	C2	C3	C4	C5
	Abrasive Flow Rate	Nozzle Distance	Transverse speed	MRR	SNRA2
1	320	1.0	350	613.88	55.7617
2	320	1.5	500	571.49	55.1402
3	320	2.0	650	613.36	55.7543
4	470	1.0	500	577.30	55.2280
5	470	1.5	650	642.79	56.1614
6	470	2.0	350	604.98	55.6348
7	620	1.0	650	671.41	56.5398
8	620	1.5	350	631.67	56.0098
9	620	2.0	500	590.33	55.4219

Table – Calculated Signal to Noise Ratios for Larger is better

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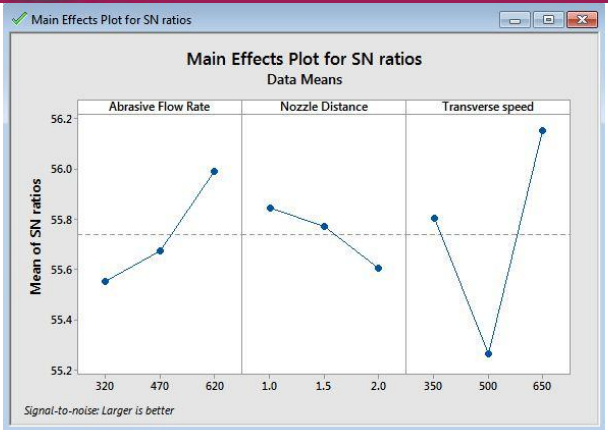

Fig - Effect of machining parameters on MRR for S/N ratio for Larger is better

CONCLUSION

Experiments are conducted on the Al 7075 alloy work pieces by varying parameters. The process parameters varied and their respective values are Abrasive flow rate 320g/min, 470g/min, 620g/min, Standoff Distance 1mm, 1.5mm, 2mm, and Transverse Speed 350mm/min, 500mm/min, 650mm/min. Other parameters are kept constant such as Abrasive size = 80 mesh [garnet], Orifice = 0.35 mm, Water pressure = 3500bar and Coolant = Ro-purified water. The optimization is done by using Taguchi technique and ANOVA considering L9 orthogonal array. Optimization is done in Minitab software. HRD and MRR tests are performed on the pieces.

From the Optimization techniques, the following results can be obtained:
From Taguchi Method, for maximum HRD, the optimum Abrasive Flow Rate is 620g/min, Standoff Distance is 1mm and transverse speed is 650mm/min. For maximum MRR, the optimum Abrasive Flow Rate is 620g/min, Standoff Distance is 1mm and transverse speed is 650mm/min.

From ANOVA, for maximum HRD here we can observe the R-sq (adj) is 23.16% and while coming to MRR the optimum observed the R-sq (adj) is 93.63%. And while coming to the HRD here the effect of Abrasive Flow Rate is more as this is described as the lesser p value in the analysis of variance. This describes that the change of Abrasive Flow Rate will affect the optimum value of the HRD. While coming to the MRR here the effect of Transverse Speed is more as this is described as the lesser p value in the analysis of variance. This describes that the change of Transverse Speed will affect the optimum value of the MRR.

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