International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 5.22 (SJIF-2017), e-ISSN: 2455-2585
Volume 5, Issue 01, January-2019

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

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ABSTRACT
In this report, we are doing different experimentations are being performed on Titanium alloy by changing the parameters like Sand Feed, Sand Speed, Stand Off Distance (i.e) Nozzle to work piece distance to determine the Material Removal rates & surface finish. Optimization is done using L9orthogonal array by using the Taguchi method to obtain the better parameters and to obtain maximum removal rates & minimum surface roughness.
The parameters considered are Sand Speed 300rpm, 500rpm, 700rpm, Standoff Distance 1mm, 2mm, 3mm, and Feed 280mm/min, 400mm/min, 770mm/min.

INTRODUCTION

AJM

Here in AJM process the work piece is removed using the erosion of high velocity abrasive particles in which the high pressure of air or gas is carried out through a small nozzle on to the work piece.

EXPERIMENTAL METHODLOGY

EXPERIMENTAL SET-UP

Experimentation is conducted by machining Titanium pieces by varying the process parameters considered Sand Speed, Sand Feed and Standoff Distance (distance between nozzle and work piece), and their performance is measured by determining material removal rate and Surface Roughness.

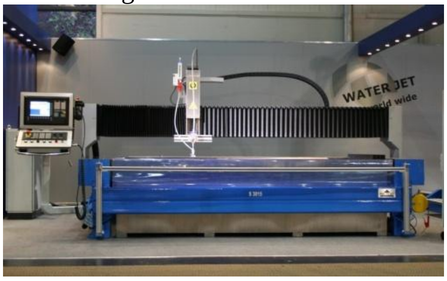

Fig – Water Jet Machine Model Number: S3015

PARAMETERS USED FOR MACHINING

Job No.	Sand Speed (rpm)	Sand Feed (g/min)	Nozzle Stand off Distance (mm)
1	300	280	1
2	300	400	2
3	300	770	3
4	500	280	2
5	500	400	3
6	500	770	1
7	700	280	3
8	700	400	1
9	700	770	2

Table – Process Parameters taken for machining

EXPERIMENTATION PHOTOS

Fig – Setting of work piece on the machine

Fig – Garnet Mesh Size

Fig – Preparing the cutter for machining

Fig – Display of work piece positions while machining

Fig – Switch Display

Fig – Switch Display

Fig – NC Program

Fig 3.9– Piece to be machined

Fig 3.10– Cutter at the zero position

Fig 3.11– Machining process

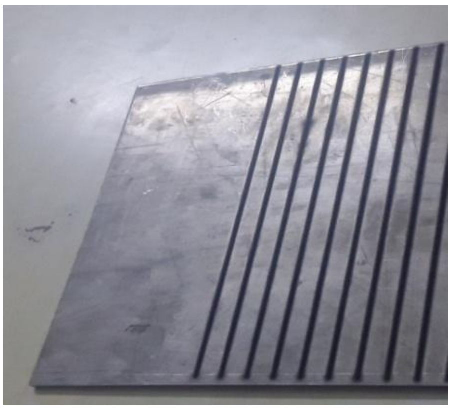

Fig – Final piece with 9 cuts

Job No.	Sand Speed (rpm)	Sand Feed (g/min)	Nozzle Stand off Distance (mm)	Surface Finish Values R_a µm
1	300	280	1	1.9
2	300	400	2	2.4
3	300	770	3	2.9
4	500	280	2	2.65
5	500	400	3	3.22
6	500	770	1	3.08
7	700	280	3	2.84
8	700	400	1	3.01
9	700	770	2	3.31

Table – Measured Surface Roughness values for experimental data

CALCULATION OF MATERIAL REMOVAL RATES

Here we can calculate the MRR by using

Initial weight of the work piece before starting the machining = ρ * V

Here ρ = density (g/mm^3)

V = volume (mm^3)

Below table shows the weight of the work piece after machining and the time taken to cut the work piece.

Job No.	Sand Speed (rpm)	Sand Feed (g/min)	Nozzle Standoff Distance (mm)	Sand Speed (rpm)	Time Taken (Sec)	Weight (gms)
1	300	280	1	300	0.217	133.65
2	300	400	2	300	0.198	132.165
3	300	770	3	300	0.115	115.83
4	500	280	2	500	0.221	99.495
5	500	400	3	500	0.156	83.16
6	500	770	1	500	0.0941	66.825
7	700	280	3	700	0.185	50.49
8	700	400	1	700	0.106	34.155
9	700	770	2	700	0.0712	17.82

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

The calculated MRR values are shown below table.

Job No.	Sand Speed (rpm)	Sand Feed (g/min)	Nozzle Standoff Distance (mm)	Sand Speed (rpm)	MRR (mm^3/sec)
1	300	280	1	300	15207.37
2	300	400	2	300	1666.66
3	300	770	3	300	33497.584
4	500	280	2	500	16425.339
5	500	400	3	500	23269.23
6	500	770	1	500	38575.98
7	700	280	3	700	19621.621
8	700	400	1	700	33302.75
9	700	770	2	700	50983.146

Table – Calculated MRR values for experimental data

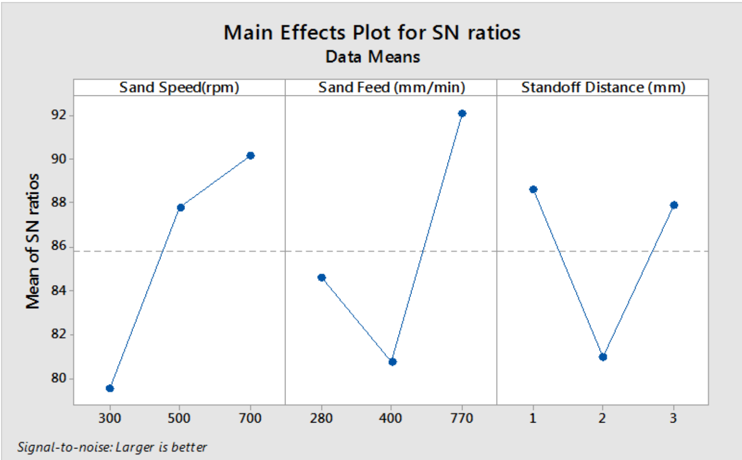

Fig - Effect of machining parameters on MRR for S/N ratio for Larger is better

Taguchi Analysis: MRR (mm3/sec) versus Sand Speed(rpm), Sand Feed (mm/mi, Standoff Distance
Response Table for Signal to Noise Ratios
Larger is better

Level	Sand Speed(rpm)	Sand Feed (mm/min)	StandoffDistance (mm)
1	79.53	84.60	88.61
2	87.79	80.74	80.97
3	90.15	92.13	87.90
Delta	10.62	11.38	7.64
Rank	2	1	3

RESULTS

The MRR is considered as the quality characteristic with the concept of "the larger-the-better".

Analysis and Discussion

Regardless of the type of the performance features, a higher S/N value agrees to a better performance. Therefore, the optimum level of the machining limitations is the level with the utmost value.

Sand Speed:-The effect of parameter Sand Speed on MRR is shown above figure S/N ratio. So the optimum Sand Speedis 700rpm

Sand Feed:-The effect of parameter Sand Speedon MRR is shown above figure S/N ratio. So the optimum Sand Speedis 770rpm

Standoff Distance:-The effect of parameter Standoff Distance on MRR is shown above figure S/N ratio. So the optimum Standoff Distanceis 1mm

SURFACE ROUGHNESS

In this project, Taguchi method is used to optimize the process parameters Thickness, Feed rate, Pressure, Water Exit Velocity and Nozzle Standoff Distance for lesser Surface Roughness values. The optimization is done in Minitab 17 software.

Job No.	Sand Speed (rpm)	Sand Feed (g/min)	Nozzle Standoff Distance (mm)	Surface Finish Values R_a µm
1	300	280	1	1.9
2	300	400	2	2.4
3	300	770	3	2.9
4	500	280	2	2.65
5	500	400	3	3.22
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Table – Measured Surface Roughness values for experimental data

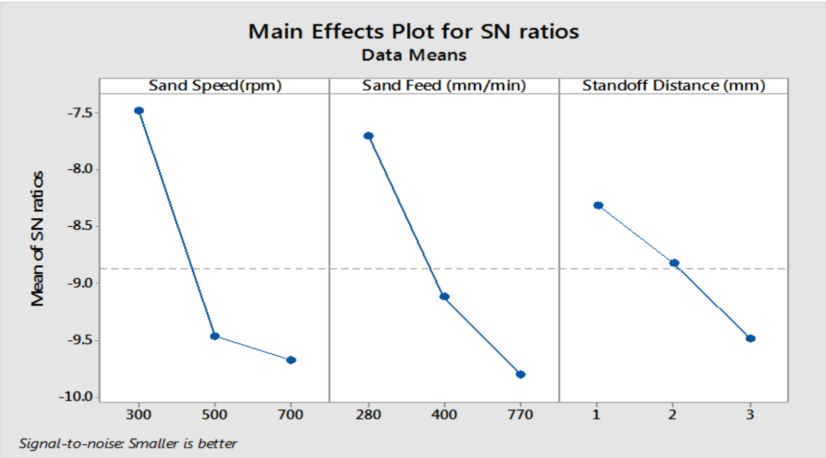

Fig - Effect of machining parameters on Surface Roughness for S/N ratio for Smaller is better

Taguchi Analysis: Surface Roughness versus Sand Speed(rpm), Sand Feed (mm/mi, Standoff Distance

Response Table for Signal to Noise Ratios
Smaller is better

Level	Sand Speed(rpm)	Sand Feed (mm/min)	StandoffDistance (mm)
1	-7.476	-7.702	-8.306
2	-9.464	-9.111	-8.822
3	-9.678	-9.805	-9.490
Delta	2.202	2.103	1.185
Rank	1	2	3

RESULT

The Surface Roughness is measured as the excellence characteristic with the concept of "the smaller-the-better".

Analysis & Discussion

Irrespective of the category of the performance features, a higher S/N value agrees to a improved performance. Therefore, the optimum level of the machining limitations is the level with the greatest value.

Sand Speed:-The result of limitation Sand Speed on Surface Roughness is displayed in the above fig as S/N ratio curve. So the optimal Sand Speed is 300rpm.

Sand Feed:-The effect of parameter Sand Speed on Surface Roughness is shown above figure S/N ratio. So the optimum Sand Speed is 280rpm.

Stand-off Distance:-The result of parameter Standoff Distance on Surface Roughness is given above in S/N ratio curve. So the optimum Standoff Distance is 1mm.

CONCLUSION

In this thesis, different experiments are performed on Titanium work piece by varying various parameters to determine Material Removal rates and Surface Roughness. The parameters considered are Sand Speed 300rpm, 500rpm, 700rpm, Standoff Distance 1mm, 2mm, 3mm, and Feed 280mm/min, 400mm/min, 770mm/min.
Optimization is done using L9 orthogonal array by Taguchi technique to determine better parameters to obtain maximum material removal rates and lesser surface roughness values.
From the resulted thesis of Taguchi method, the following result obtained is:
The effect of Sand Speed and Sand feed on Surface Roughness and MRR are more than standoff distance.
For the min SR, the optimal sand speed is 300rpm, the optimum Sand Feed is 280mm/min and the optimum Standoff Distance is 1mm.
For Maximum MRR, the optimum Sand Speed is 700rpm, the optimum Sand Feed is 770mm/min and the optimum Standoff Distance is 1mm.

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