

INTERNATIONAL RESEARCH JOURNAL OF SCIENCE ENGINEERING AND TECHNOLOGY



ISSN 2454-3195

An Internationally Indexed Peer Reviewed & Refereed Journal

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Published by iSaRa Solutions

INVESTIGATION OF PROCESS PARAMETERS IN AJM ON OHNS**P. R. PADAVE¹, N K KAMBLE²**

1, 2: Asst Prof., D Y Patil College of Engineering, Akurdi, Pune-44
pradnesh.padave1989@gmail.com, nkkamble11@rediffmail.com

Abstract – *Abrasive Jet Machining (AJM) is the material removal process from a workpiece by using high speed stream of abrasive particles carried in a gas medium from a nozzle. The material removal is mainly by erosion.*

OHNS is one of the hardened material used in many applications. It is having good mechanical properties and high wear resistance because of this, it is widely used in die and punch manufacturing. This paper includes analysis of process parameters using Regression method.

Keywords - Abrasive waterjet machining, Surface Roughness, Response Surface Methodology.

1 Introduction

Producers of machined components and manufactured goods are continually challenged to reduce cost, improve quality and minimize setup times in order to remain competitive. Frequently the answer is found with new technology solutions. Such is the case with grinding where the traditional operations involve expensive machinery and generally have long manufacturing cycles, costly support equipment, and lengthy setup times. However, the grinding process itself may require several machine tools and several setups to finish all component surfaces. Because grinding can be a slow process with low material-removal rates, there has been a determined search for replacement processes.^{[5][7]}

The newer solution is a hard machining by abrasive water jet machining, which is best performed with appropriately configured. Hard part machining really started to develop at the beginning of the nineties. The reason for this was the availability of new techniques was rigid, stable and accurate enough to successfully finish hard machining.^[3]

AWJM is normally used for Paint removal, Cutting soft materials, Cutting frozen meat, Mass Immunization, Surgery, Cutting, Nuclear Plant Dismantling, Pocket Milling, Drilling, Turning, Textile, Leather industry. Materials which are cut by AWJM are Steels, Nonferrous alloys, Ti alloys, Ni- alloys, Polymers, Honeycombs, Metal Matrix Composite, Ceramic Matrix Composite, Concrete, Stone Granite, Wood, Reinforced plastics, Metal Polymer Laminates, Glass Fibre Metal Laminates.

2 OBJECTIVE

To observe the impact of process parameters in abrasive waterjet machining on Oil Hardened Nitride Steel. Setting up the Parameters i.e. Water Pressure, Traverse Speed, Mass flow rate and standoff distance for hard machining of OHNS.

3 DESIGN VARIABLE

Response Parameters: Surface Roughness

Machining parameters and their levels are plotted in table below

Table 1: Levels of Process parameters^[15]

Level Parameters	1	2	3	4	5
Water Pressure (MPa)	150	200	250	300	350
Transverse Speed (mm/Sec)	0.3	0.4	0.5	0.6	07
Mass Flow Rate (g/s)	7	8	9	10	11
Sandoff Distance (mm)	1	2	3	4	5

4. EXPERIMENTAL SETUP

Machine used for experimentation is model KMT



Fig. 1: Abresive waterjet Machine

Workpiece used for operation is OHNS ϕ 32mm X 20 mm.



Fig.2: Workpiece OHNS

80 Mesh abrasive particles are used to cut workpiece.



Fig.3 Abrasive Used 80 Mesh

Setup of AJM process is shown in fig. 4



Fig.4 Machining Setup

5 RESULT AND DISCUSSION

The design and experiment plan is shown in following table

The Response and Surface methodology is used to create the DOE Plan. Surface Roughness "Ra" measured in shown below

Table No.2: Design of Experiment Plan

Mitutoyo Surface Roughness tester is used for measuring surface roughness value.

ANOVA Table obtained by processing statistical analysis

Table 3. : ANOVA Table

Run Order	Water Pressure	Traverse Speed	Massflow Rate	Sandoff distane	Ra (μm)
1	250	0.7	9	3	1.29
2	300	0.4	10	2	1.6
3	250	0.5	9	3	1.62
4	300	0.6	10	4	0.99
5	250	0.5	9	1	1.52
6	300	0.4	8	2	2.12
7	200	0.4	10	4	1.59
8	250	0.5	9	3	1.55
9	250	0.5	9	3	1.65
10	200	0.6	10	2	1.23
11	200	0.4	8	2	1.42
12	350	0.5	9	3	1.63
13	200	0.4	10	2	1.57
14	250	0.5	9	3	1.62
15	300	0.6	10	2	0.91
16	200	0.4	8	4	1.13
17	200	0.6	8	4	1.68
18	150	0.5	9	3	1.71
19	300	0.6	8	2	1.67
20	200	0.6	10	4	1.79
21	250	0.5	11	3	1.39
22	250	0.5	9	3	1.61
23	300	0.4	8	4	1.31
24	300	0.4	10	4	1.36
25	250	0.5	9	3	1.62
26	200	0.6	8	2	1.37
27	250	0.3	9	3	1.51
28	300	0.6	8	4	1.45
29	250	0.5	9	5	1.39
30	250	0.5	7	3	1.57
31	250	0.5	9	3	1.66

	DF	Adj SS	Adj MS	F-Value	P-Value
Model	13	1.65	0.13	47.190	0.000
Linear	4	0.22	0.055	47.19	0.000
Water Press.	1	0.01	0.01	20.43	0.052
Travr. Speed	1	0.09	0.09	4.36	0.000
Mass flow rate	1	0.09	0.09	32.62	0.000
Sand	1	0.03	0.03	33.53	0.004

off Dist.					
Square	3	0.21	0.07	11.21	0.000
Travr.	1	0.12	0.12	25.72	0.000
Mass flow	1	0.06	0.06	43.75	0.000
Sand off	1	0.07	0.072	20.60	0.000
2-Way	6	1.22	0.20	26.91	0.000
Water Pressr.* Travr. Speed	1	0.19	0.19	75.76	0.000
Travr Speed* Mass flow rate	1	0.12	0.121	74.57	0.000
Travr Speed* sand \off dist.	1	0.26	0.263	44.97	0.000
Mass flow rate * sand off dist.	1	0.13	0.128	97.81	0.000
Error	17	0.05	0.003	-	-
Lack of Fit	11	0.038	0.003	2.780	0.110
Pure Error	6	0.007	0.001		

S	R-Sq	R Sq-Adj	R-Sq Predicted
0.0518205	97.30 %	95.24%	87.81%

Regression analysis equation obtained by analysis is

$$Ra = -13.23 + 0.04262 \text{ Water Pressure} + 15.15 \text{ Traverse Speed} + 1.602 \text{ Massflow rate} - 0.621 \text{ sandoff distane} - 6.374 \text{ Traverse Speed*Traverse Speed} - 0.04374 \text{ Massflow rate*Massflow rate} - 0.04999 \text{ sandoff distane*sandoff distane} - 0.02163 \text{ Water Pressure*Traverse Speed} + 0.002837 \text{ Water Pressure*Mass flow rate} - 0.002237 \text{ Water Pressure*sandoff distane} - 0.869 \text{ Traverse Speed*Massflow rate} + 1.281 \text{ Traverse Speed*sandoff distane} + 0.0894 \text{ Massflow rate*sandoff distane}$$

The ANOVA table indicates that, water pressure is insignificant as it shows the P-Value more than, 0.05.

The theory on statistical analysis says that, the confidence level of success in 95% and remaining 5% define error.^[12]

P-Value indicates probability on null hypothesis, and the ANOVA table shows that water pressure is insignificant and rest all parameters are significant.

The lack of fit value is more than 0.05 proves that the model is statistically fit.

The R-square values are more than 80% indicates, the chances of getting successive output in more than 80%.

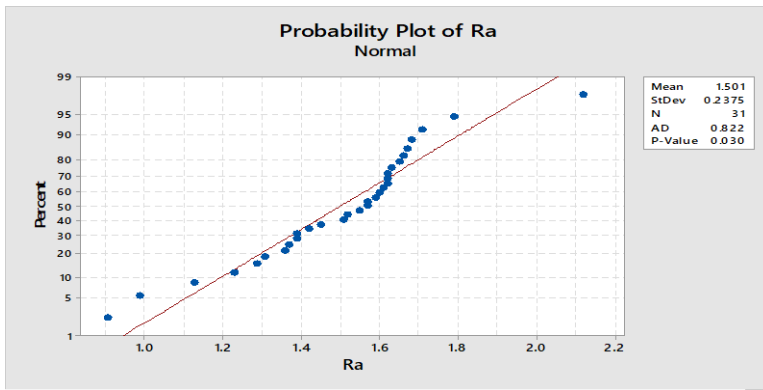


Fig 5: Normal Probability chart of “Ra”

In above chart we can observe that, out of 31 observations 3 points are apart from line. And they consider are outliers.

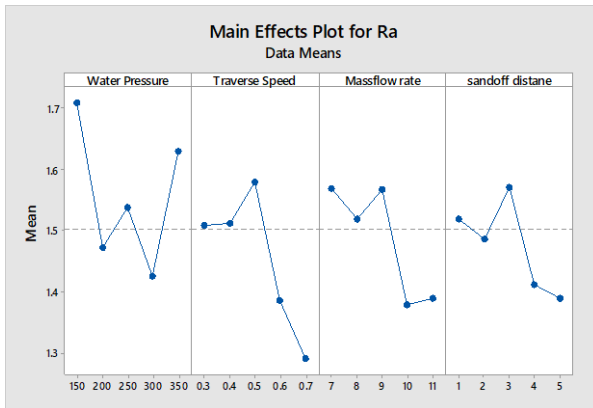


Fig 6 Main Effect plot of Ra against all parameters

The plot shows variation of individual responses with five parameters. The main effects plot used to determine the optimal design conditions to obtain the optimum value of “Ra”. It shows that, increasing and decreasing pattern on surface roughness, this shows the significant influence of all parameters on “Ra”.

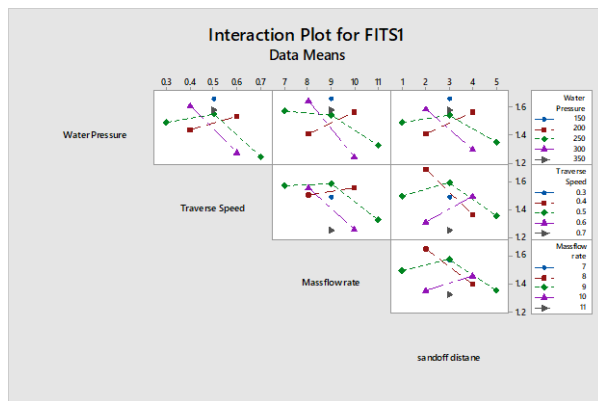


Fig 7 Main Effect plot of Ra against all parameters

Main Effect Plot shows that, All two level interaction shows that, they have crossing to each other, Indicates they are having significance on Surface roughness "Ra".

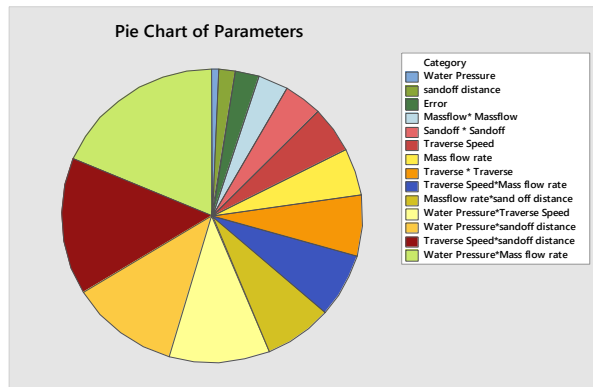


Fig 8 Percentage Contribution Management

The above pie chart expresses the percentage contribution of parameter and the interactions on Surface Roughness "Ra". Percentage contribution column shows that, the Two Way interactions are having a maximum contribution of 70.6%. Rests of the parameter are contributed 29.4%.

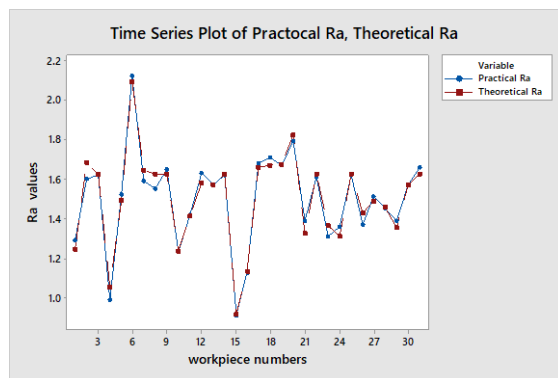


Fig. 9 Time Series analysis of Practical Ra and Theoretical Ra

The above plot shows the observation points obtained by Experimental and theoretical results for "Ra". The graph is plotted by using Time-Series plot in Minitab. The observation shows that Experimental and theoretical results are close enough i.e. it is having less error.

Conclusion

Experimental investigation and statistical analysis of the Abrasive waterjet Machining on the surface roughness on Oil hardened Nitride Steel has been carried out.

The results obtained from the data analysis indicate that the Sandoff Distance, Mass Flow Rate, Traverse Speed values have a significant effect on the surface roughness.

The analysis for Surface Roughness indicates that, the Two Level Interactions having maximum contribution on surface roughness, 70.6 % followed by the Rest other parameters 29.4 %, The

response surface model fits the experimental data very well with coefficient of correlation nearing 97.30 %, $R^2(\text{adj}) = 95.24\%$ and $R^2(\text{predicted}) = 87.781\%$ and lack of fit as insignificant.

Surface roughness values predicted by the regression equations are very close to the experimental values, thus indicating that the regression equation represent the experimental data accurately

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