Optimization of control Parameter in Abrasive Water Jet Machining (AWJM) by Using Taguchi Methodology on Aluminum 6351.

Amit Hazari[1], DebabrataDas[2], PritamPain[3]

[1,2] *M.Tech Student, Haldia Institute of Technology, India,*
[3] *Assistant Professor, Haldia Institute of Technology, India.*

Abstract - *As the modern day the technology are approaching with high accuracy with at the same time with low material costing, non-traditional machining is very much essential to sustain in this modern manufacturing system. Abrasive Water Jet Machining (AWJM) is one such machining. This AWJM process is controlled by several process control parameters like, water pressure, Stand-off Distance, traverse speed of the abrasive particle etc. To optimize this complicated process, there are several procedures are introduced in this research field. In this research paper Taguchi design is applied to optimize the process parameters of Aluminium6351 for (AWJM). The final objective of the paper is to decrease the roughness of the product, as this AWJM process is used for the final machining process. So, there will be no need of other surface finishing process to increase the precession of the finished product.*

Key Words: Abrasive Water Jet Machining (AWJM), Taguchi Method, ANOVA, Aluminium6351.

1. INTRODUCTION

Abrasive water jet machining is non-traditional material removal process in which material is removed from the workpiece surface by the high jet pressure of water and coarse mixture of the abrasive particles. In this process the mixture of abrasive and water directly strike on the workpiece surface and as a result the surface gets eroded and the chip is flushed away by the same flow of the water mixture. This type of machining is suitable for machining brittle material with complex shape. Figure 1 shows the layout of the water jet machining.

There are several researches have done on AWJM to optimize the control parameters Stand-off Distance SoD, water pressure, type of abrasive, abrasive size, mixing ratio to optimize the material removal rate, surface integrity etc.

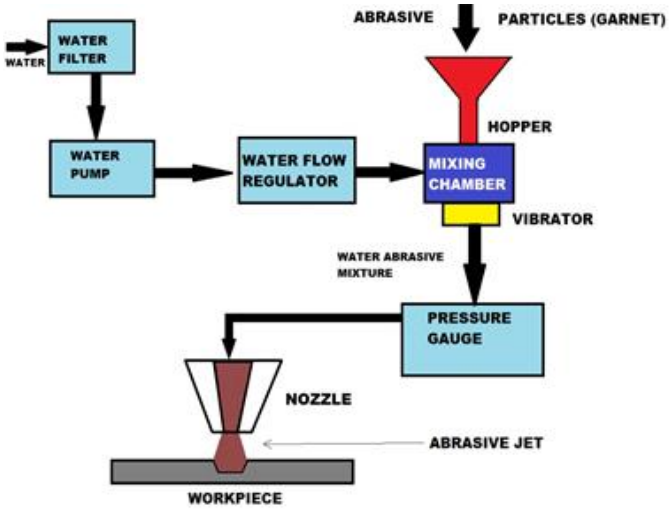

Fig -1: Abrasive Water jet machining.

2. EXPERIMENT SETUP

In this research work the abrasive water jet machine was used (maker DARDI WATER CUTTER CO.LTD, MAKE DWJ 1525 repetitively accuracy + 0.025mm) to experiment where the jet pressure can regulate up to 60000psi which can pass through a carbide nozzle of 0.8 mm focus tube diameter. The workpiece material is Aluminium 6351 and Garnet of mesh size 80.

Table -1: The chemical composition of the Aluminum 6351 alloy is tabulated below.

Element	Content (%)
Aluminum (Al)	97.8
Silicon (Si)	1
Manganese (Mn)	0.6
Magnesium (Mg)	0.6

Table 2: The mechanical properties of the Aluminum 6351 alloy are outlined in the following table.

Properties	Metric
Tensile strength	280MPa
Yield strength	150MPa
Shear strength	200MPa
Fatigue strength	90MPa
Elastic modulus	70-80GPa

Poisson 's ratio	0.033
Elongation	20%
Hardness	95
Density	2.6-2.8g/cc

EXPERIMENTAL DESIGN

The Design of Experiment (DoE) is most important criteria to evaluate the results with minimum number of experiment and minimum experimental cost but maximum output variance. In this work Taguchi methodology is used to optimize Ra while the control parameters are Pressure, Traverse Rate, and SoD. Table 1 shows the experimental results.

Table -3: Experimental results with control parameters

Exp. No.	Control Parameters			Response
	Pressure (MPa)	SoD (mm)	Traverse speed (mm/min)	Ra (µm)
1	150	2.5	90	7.17425
2	150	3.5	150	8.78925
3	150	4.5	210	10.06945
4	220	2.5	150	5.99975
5	220	3.5	210	6.77535
6	220	4.5	90	6.22525
7	290	2.5	210	3.92645
8	290	3.5	90	3.71775
9	290	4.5	150	3.82135

TAGUCHI METHODOLOGY

The Taguchi methodology is one of the best DoE to analyse the response parameters with the minimum variance where the process is not linearly related to the control parameters. This methodology is based on Analysis of Variance (ANOVA) and Signal to Noise ratio (S/N ratio).

ANOVA

ANOVA is a powerful tool to find out the effect of different control parameters on the responses where the control parameters are varied with a given range.

RESULT ANALYSIS

Table 2: Experimental result of ANOVA

Source	DF	Adj SS	Adj MS	F-Value	%-Value
Pressure	2	35.3822	17.6911	51.79	0.019
SOD	2	1.6166	0.8083	2.37	0.297
Speed	2	2.2501	1.125	3.29	0.233
Error	2	0.6832	0.3416		
Total	8	39.9321			

From the above experimental results, the roughness is considered as the response where the control parameters are varied in three levels. So, the degree of freedom (DF) for each control parameter is 2. The adjusted sum-square (Adj SS) for the pressure is maximum, that's why also the adjusted mean-square (Adj MS) maximum. As the F-Value of the pressure is maximum so it is clearly visible that the pressure most significant parameter for the Ra followed by traverse speeds and SoD.

SIGNAL TO NOISE RATIO

Signal to noise ratio is a powerful tool to eliminate the different noise of control parameter. The main aim of this method is to find optimum combination of input factor setting to achieve robust design. There are different types of S/N ratio like larger is better, smaller is better etc. As the roughness is to minimize in order to better surface finish, in this experiment we used smaller is better option.

RESULT ANALYSIS

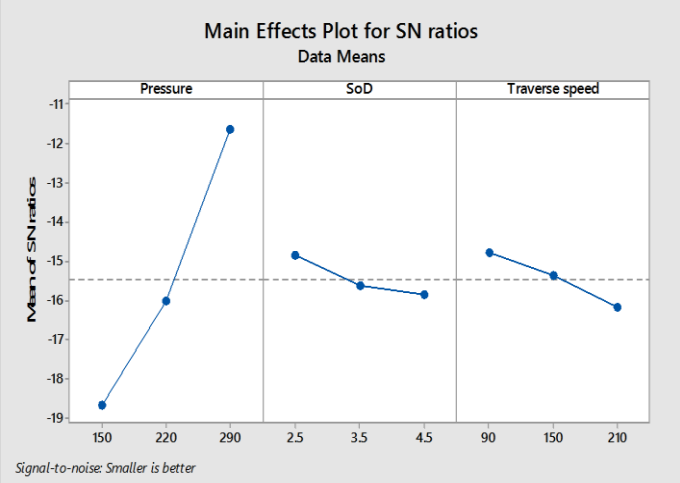

Chart -1: S/N Ratio analysis for Ra

According to the above graphs the Ra increases with increase of pressure while decrease with the increase of other two parameters. The best parametric combination for the lowest Surface Roughness (Ra) when pressure is 150 MPa, SoD of 4.5 mm and Traverse speed of 210 mm/min.

3. CONCLUSIONS

From the above experimental result, it can be concluded that the pressure is the most significant parameters for the Ra while machining any material through AWJM. It can also visible that the pressure increases Ra while other two parameters decrease.

As the AWJM is very complex machining process and in this research paper only three control parameters are considered to optimize the roughness. So, this machining process can further optimize while considering different process control parameters and different responses.

REFERENCES

[1] Iqbal, A., N.U.Dar, Hussain, G. Optimization of Abrasive Water Jet Cutting of Ductile Materials, Wuhan University of Technology and Springer-Verlag Berlin Heidelberg, 2011.

[2] Azmir, M.A. & Ahsan, A.K. 2007. Investigation on glass/epoxy composite surfaces machined by abrasive water jet machining, Journal of Materials Processing Technology.

[3] Badgujar, P. P & Rathi, M. G (2014)"Abrasive Water jet Machining-A State of Art", IOSR Journal of

[4] Bauri, R. (2009). Synthesis of Al –Tic in-situ composites: Effect of processing temperature and Tic ratio. Transactions of the Indian Institute of Metals.

[5] Bose, G. K., & Mahapatra, K. K. (2014). Parametric study of Die Sinking EDM process on AISIH13 tool steel using statistical techniques. Journal of Advances in Production Engineering and Management.

[6] B.P Vinod, Patel V.A. Parametric analysis of Abrasives water jet machining ofEN8 Material "International Journal of Engineering Research and Applications (IJERA).

BIOGRAPHIES

Amit Hazari is M.Tech student of Mechanical Engineering Department in Haldia Institute of Technology, Haldia, India. He received his B.Tech degree in Mechanical Engineering from Surya School of Engineering and Technology College Punjab India in year 2015.

Debabrata Das is M.Tech student of Mechanical Engineering Department in Haldia Institute of Technology, Haldia, India. He received his B.Tech degree in Mechanical Engineering from Institute of Science and Technology College West Bengal India in year 2017

Pritam Pain is Assistant Professor in Mechanical Engineering Department, Haldia Institute of Technology, Haldia, India. He received his BE degree in Mechanical engineering with from Dr. Sudhir Chandra Sur Degree Engineering College, West Bengal India in the year 2014 and M.Tech degree in Manufacturing Technology from Haldia Institute of Technology, Haldia, India. In the year of 2016