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Parametric Optimization of Abrasive Water Jet Cutting during Machining of AISI4140 steel

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Abstract — ***Abrasive water jet Machining (AWJM) is one of the widely used non-traditional machining process. It is capable of machining geometrically complex and hard material components, that are precise and difficult-to-machine such as heat-treated tool steels, composites, super alloys, ceramics, carbides, heat resistant steels etc. being widely used in die and mould making industries, aerospace, and aeronautics industries. In present study, Experimental investigations were conducted to assess the influence of process parameters like Abrasive mass flow rate(gm/min), traverse speed (mm/min) and Stand of Distance (mm) on Material Removal Rate (mm^3/min) and Surface Roughness (µm) of AISI 4140 steel. Here, using garnet and Aluminium oxide mixer as an abrasive material. The optimization for Abrasive water jet Machining process parameters of AISI 4140 Steel work piece using Taguchi method will done. Thirty-two experimental runs (L32) based on an orthogonal array Taguchi method will performed and investigate the effect of Abrasive water jet cutting process parameters like Abrasive size (mesh). Abrasive mass Flow Rate (gm/min), Traverse speed (mm/min) and Stand of Distance (mm) on Material Removal rate, Surface Roughness and Kerf width. The MRR, SR and kerf width were measured for each specimen after AWJC and the effects of these parameters were researched.***

Keywords- Abrasive water jet cutting, abrasive size, Pressure, Transverse speed, Stand of Distance, Surface roughness, Material Removal Rate, Kerf width

I. INTRODUCTION

Abrasive water jet (AWJ) technology and its applications had been commercialized since long. Since then, significant advances have been made in AWJM in the form of hardware and software integration, abrasive suspension jet machining (ASJM), cryogenic abrasive water jets, super-water jetting, percussive (rapidly pulsing jets) machining, and oscillation pulsed jet along with newer applications in drilling, milling, taper cutting, turning, threading, etc. A wide range of materials (Inconel, Titanium, Incoloy, glass, ceramics, composites, heat-sensitive alloys, etc.) is shaped for different applications with this process. The demand of higher strength and heat resistant material is increasing particularly in aerospace industries. However, these materials are often difficult to machine due to their physical and mechanical properties such as high strength and low thermal conductivity, which requires very high cutting energy and makes the cutting forces and cutting temperature very high, and even leads to a short tool life. [1]

II. EXPERIMENTAL SETUP

Figure 1 Abrasive water jet machining

Table 1 Orthogonal array Taguchi L32

Sr no	Abrasive size [mesh]	Pressure [MPa]	Traverse speed [mm/min]	Sod [mm]
1	80	250	50	2
2	80	250	75	3
3	80	250	100	4
4	80	250	125	5
5	80	350	50	2
6	80	350	75	3
7	80	350	100	4
8	80	350	125	5
9	80	450	50	3
10	80	450	75	2
11	80	450	100	5
12	80	450	125	4
13	80	550	50	3
14	80	550	75	2
15	80	550	100	5
16	80	550	125	4
17	120	250	50	5
18	120	250	75	4
19	120	250	100	3
20	120	250	125	2
21	120	350	50	5
22	120	350	75	4
23	120	350	100	3
24	120	350	125	2
25	120	450	50	4
26	120	450	75	5
27	120	450	100	2
28	120	450	125	3
29	120	550	50	4
30	120	550	75	5
31	120	550	100	2
32	120	550	125	3

III. Analysis of Variance (ANOVA)

Above analysis shows the percentage contribution of individual parameters on surface roughness. The percentage contribution of is Abrasive size 8.5 %, Pressure is 59.3 %, Transverse rate is 28.9 % and Sod is 0.2 %. And error is 3.07 %. this error is due to human ineffectiveness.

Above analysis shows the percentage contribution of individual parameters on MRR. The percentage contribution of is Abrasive size5.9 %, Pressure is 30.8 %, Transverse rate is 50.4% and Sod is 0.6 %. And error is 12.27 %. this error is due to human ineffectiveness.

Above analysis shows the percentage contribution of individual parameters on Top kerf width. The percentage contribution of is Abrasive size 15.5 %, Pressure is 25.9 %, Transverse rate is 49.1 % and Sod is 1.1 %. And error is 8.4 %. this error is due to human ineffectiveness.

Above analysis shows the percentage contribution of individual parameters on Bottom kerf width. The percentage contribution of is Abrasive size1.0 %, Pressure is 61.4 %, Transverse rate is 20.3 % and Sod is 3.0 %. And error is 14.24 %. this error is due to human ineffectiveness.

IV. REGRESSION ANALYSIS

Surface roughness = 2.78 -0.00163(Abrasive size) + 0.000710 (Pressure)-0.00214 (Traverse Speed) + 0.00125(SOD)

Material Removal Rate = 0.696 - 0.00928 (Abrasive size) + 0.00353 (Pressure) + 0.0182 (Traverse Speed) - 0.0347(SOD)

Top Kerf Width = 0.508 + 0.000828(Abrasive size) + 0.000191(Pressure) + 0.00105 (Traverse Speed) - 0.00338(SOD)

Bottom Kerf Width = 0.451 + 0.000250 (Abrasive size) + 0.000307(Pressure) + 0.000670 (Traverse Speed) + 0.00775(SOD)

V. Optimization methodology using grey relational analysis

Table 2 Grey relational coefficient and grey relational grade values

Run No.	deviation sequence				Grey Relation Coefficient				grey relation grade	rank
	Surface Roughness	Material Removal Rate	Top Kerf Width	bottom kerf width	Surface Roughness	Material Removal Rate	Top Kerf Width	bottom kerf width		
1	0.43	0.76	0.00	0.00	0.538	0.395	1.000	1.000	0.298	29
2	0.26	0.73	0.00	0.15	0.656	0.408	1.000	0.769	0.284	30
3	0.19	0.51	0.12	0.30	0.724	0.493	0.810	0.625	0.281	32
4	0.07	0.37	0.24	0.45	0.875	0.576	0.680	0.526	0.281	31

5	0.74	0.57	0.00	0.10	0.404	0.467	1.000	0.833	0.352	27
6	0.67	0.37	0.18	0.25	0.429	0.576	0.739	0.667	0.365	26
7	0.57	0.29	0.41	0.50	0.467	0.636	0.548	0.500	0.442	18
8	0.43	0.23	0.59	0.65	0.538	0.690	0.459	0.435	0.473	15
9	0.95	0.79	0.18	0.45	0.344	0.387	0.739	0.526	0.593	5
10	0.86	0.37	0.35	0.55	0.368	0.576	0.586	0.476	0.532	12
11	0.69	0.17	0.41	0.75	0.420	0.749	0.548	0.400	0.505	14
12	0.50	0.08	0.59	0.65	0.500	0.859	0.459	0.435	0.455	17
13	1.00	0.41	0.24	0.55	0.333	0.551	0.680	0.476	0.548	8
14	0.90	0.29	0.41	0.55	0.356	0.636	0.548	0.476	0.538	9
15	0.76	0.29	0.47	0.75	0.396	0.631	0.515	0.400	0.569	7
16	0.62	0.08	0.65	0.80	0.447	0.864	0.436	0.385	0.536	10
17	0.26	1.00	0.24	0.25	0.656	0.333	0.680	0.667	0.437	20
18	0.19	0.87	0.29	0.15	0.724	0.365	0.630	0.769	0.377	25
19	0.12	0.61	0.35	0.30	0.808	0.450	0.586	0.625	0.346	28
20	0.00	0.62	0.59	0.45	1.000	0.447	0.459	0.526	0.414	23
21	0.67	0.97	0.06	0.05	0.429	0.341	0.895	0.909	0.436	21
22	0.57	0.65	0.24	0.15	0.467	0.435	0.680	0.769	0.402	24
23	0.29	0.37	0.65	0.45	0.636	0.576	0.436	0.526	0.438	19
24	0.31	0.33	0.71	0.50	0.618	0.603	0.415	0.500	0.461	16
25	0.88	0.80	0.24	0.55	0.362	0.385	0.680	0.476	0.617	3
26	0.69	0.40	0.41	0.80	0.420	0.558	0.548	0.385	0.575	6
27	0.50	0.21	0.65	0.75	0.500	0.700	0.436	0.400	0.528	13
28	0.33	0.00	0.71	0.70	0.600	1.000	0.415	0.417	0.435	22
29	0.74	0.54	0.41	0.85	0.404	0.481	0.548	0.370	0.635	2
30	0.69	0.38	0.65	0.75	0.420	0.571	0.436	0.400	0.616	4
31	0.52	0.29	0.76	0.55	0.488	0.631	0.395	0.476	0.533	11
32	0.40	0.27	1.00	1.00	0.553	0.651	0.333	0.333	0.668	1

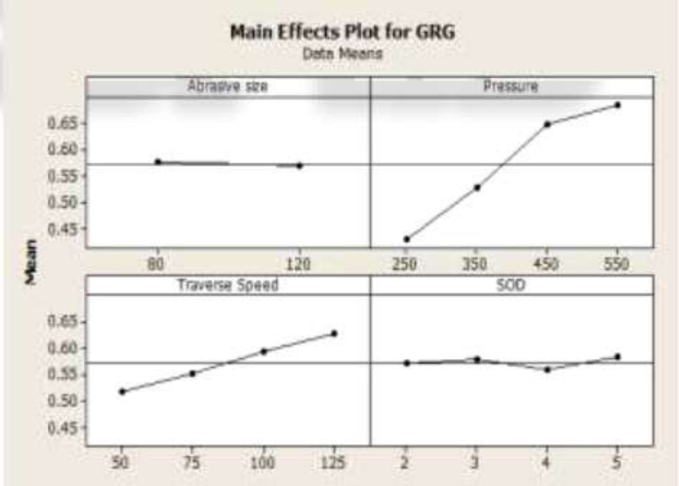

Figure 2Main effect plot of grey relational grade

VI. Conclusion

- Traverse speed is most critical variable for MRR and SR contrasted with different parameters.
- Increase of traverse speed produces more start vitality as the abrasive flow rate that the MRR rise and SR diminishes with traverse speed. Abrasive flow rate is most critical parameter in all outputs. Surface roughness likewise increments with increment of abrasive size on the grounds that the increments of abrasive size create hole with more extensive and more profound trademark.
- Traverse speed has inverse impact to abrasive size. MRR rises with increment of traverse speed, while surface roughness decreases.
- The MRR diminishes with increment in stand of distance. This is because of increment in stand of distance result in higher release vitality per start as a result of expansive abrasive particle between working crevice; subsequently the MRR diminishes.

REFERENCES

[1]. Mostafa Mohanmed "Water jet Cutting up to 900 MPa '"Hannover, in July 2004

[2]. Divyansh Patel, Puneet Tandon "Experimental investigations of thermally enhanced abrasive water jet machining of hard-to-machine metals" CIRP Journal of Manufacturing Science and Technology (2015)

[3]. Cristian birtu and valeriuavramescu "abrasive water jet cutting - technique, equipment, performances" non-conventional technologies review romania, march, 2012

[4]. M.A. Azmir, A.K. Ahsanb "A study of abrasive water jet machining process on glass/epoxy composite laminate",Journal of Materials Processing Technology 209 (2009) 6168–6173

[5]. Pandu R. Vundavillia, M.B. Parappagoudarb, S.P. Kodalic, Surekha Benguluria "Fuzzy logic-based expert system for prediction of depth of cut in abrasive water jet machining process", Knowledge-Based Systems 27 (2012) 456–464

[6]. Y.Ayed, G.Germaina, A.Ammara, B.Furetb "Tool wear analysis and improvement of cutting conditions using the high-pressure water-jet assistance when machining the Ti17 titanium alloy" Precision Engineering (2015)

[7]. M.A. Azmir, A.K. Ahsan "Investigation on glass/epoxy composite surfaces machined by abrasive water jet machining", journal of materials processing technology 198 (2008)122–128

[8]. MahabaleshPalleda "A study of taper angles and material removal rates of drilled holes in the abrasive water jet machining process", Journal of Materials Processing Technology 189 (2007) 292–295

[9]. Chidambaram Narayanan, RetoBalz, Daniel A.Weiss, Kurt C. Heiniger "Modelling of abrasive particle energy in water jet machining " ,Journal of Materials Processing Technology 213 (2013) 2201– 2210

[10]. Mustafa Kemal Kulekci "Processes and apparatus developments in industrial water jet applications International", Journal of Machine Tools &Manufacture 42 (2002) 1297–1306

[11]. Keyur kumar J. Patel "Quantitative evaluation of abrasive contamination in ductile material during abrasive water jet machining and minimising with a nozzle head oscillation technique International", Journal of Machine Tools &Manufacture 44 (2004) 1125–1132

[12]. Deaconescutudor and deaconescuandrea "optimisation of abrasive jet cutting by means of taguchi methods" Nonconventional Technologies Review Romania, december, 2013

[13]. M.ChithiraiPon Selvan, Dr. N. Mohana Sundara Raju "Assessment of Process Parameters in Abrasive Water jet Cutting of Granite" International Conference on Trends in Mechanical and Industrial Engineering (ICTMIE'2011) Bangkok Dec., 2011

[14]. FarhadKolahan, A. Hamid Khajavi "Modeling and Optimization of Abrasive Water jet Parameters using Regression Analysis" World Academy of Science, Engineering and Technology 35 2009

[15]. AzlanMohdZaina, SafianSharifc "Optimization of process parameters in the abrasive water jet machining using integrated SA–GA" Applied Soft Computing 11 (2011) 5350–5359

[16]. D.K. Shanmugam, F.L. Chen, E. Siores, M. Brandt "Comparative study of jetting machining technologies over laser machining technology for cutting composite materials",Composite Structures 57 (2002) 289–296

[17]. H. Y. Zhenga, Z. Z. Han', Z. D. Chen, W. L. Chena, S. Yeo "Quality and Cost Comparisons between Laser and Waterjet Cutting", Journal of Materials Processing Technology 62 (1996) 294-298