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Optimization of Process Parameters on Kerf Width & Taper Angle on En-8 Carbon Steel by Abrasive Water Jet Machining

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Abstract*:* Abrasive water jet machining is a process where the material is removed by the principle of erosion. In this paper, the cutting of EN-8 carbon steel was carried out by AWJM process where the input parameters are water jet pressure, abrasive flow rate and traverse speed, which are taken into consideration machining. kerf width and the kerf taper angle of EN-8 steel are measured with respect to the above-mentioned input parameters using Taguchi L9 orthogonal array Design of Experiments. In this experiment, it has been observed that the main parameter which affects the experimental values is the abrasive flow rate.

Keywords: Kerf Width, Kerf Taper Angle, Taguchi L9 Array.

1. INTRODUCTION

Abrasive water jet machining is a mechanical machining process where the material is removed by the principle of erosion. In this process, a high velocity stream of water jet mixed with abrasive is made to impinge on the target material that is to be machined. Upon the impingement of the high velocity water and abrasive jet the material from the target material is removed. In this process the water from the reservoir is pumped to the intensifier where its pressure increases up to 4 bars. The intensifier increases the pressure of water from 4 bar to about 40000 bars and above as per the requirement. The water from the intensifier is sent to the accumulator where the pressure fluctuations due to high pressures are eliminated. Then the pressurized water from the accumulator is sent to the mixing chamber through control valves. Before entering the nozzle the water is mixed with abrasives particles in mixing chamber in a proportionate ratio. This high pressure of water is converted into kinetic energy of abrasive water jet in nozzle which is made to impinge on the material which is to be machined.

2. WORKING PRINCIPLE

The Abrasive Jet Machining is a non-traditional machining process involves the application of a high-speed stream of abrasive particles assisted by the pressurized air on to the work surface through a nozzle of small diameter. Material removal takes place by abrading action of abrasive particles. Water jet machining is an erosion process technique in which water under high pressure and velocity precisely cuts through and grinds away minuscule amounts of material. The addition of an abrasive substance greatly increases the ability to cut through harder materials such as steel and titanium. Water jet Machining is a cold cutting process that involves the removal of material without heat. This revolutionary technology is an addition to non-traditional cutting processes like laser and plasma, and is able to cut through virtually any material. The water jet process is combined with CNC to precisely cut machine parts and etch designs. Abrasive water jet uses the technology of high-pressure water to create extremely concentrated force to cut stuff. A water cutter pressurizes a stream of pure water flow (without abrasive) to cut materials such as foam, rubber, plastic, cloth, carpet and wood. Abrasive jet cutters mix abrasive garnet to a pressurized water stream to cut harder materials. Examples are stainless steel, Titanium, glass, ceramic tile, marble and granite. Water jet metal cutting machine yields very little heat and therefore there is no Heat Affected Zone (HAZ). Water jet machining is also considered as "cold cut" process and therefore is safe for cutting flammable materials such as plastic and polymers. With a reasonable cutting speed setting, the edges resulting are often satisfactory. In Abrasive Water Jet Machining, the abrasive particles are mixed with water and forced through the small nozzle at high pressure so that the abrasive slurry impinges on the work surface at high velocity. Each of the two components of the jet, i.e., the water and the abrasive materials have both separate purpose and a supportive purpose. The primary purpose of the abrasive material in the jet stream is to provide the erosive forces. The water in the jet acts as the coolant and carries both the abrasive and eroded material to clear of the work.

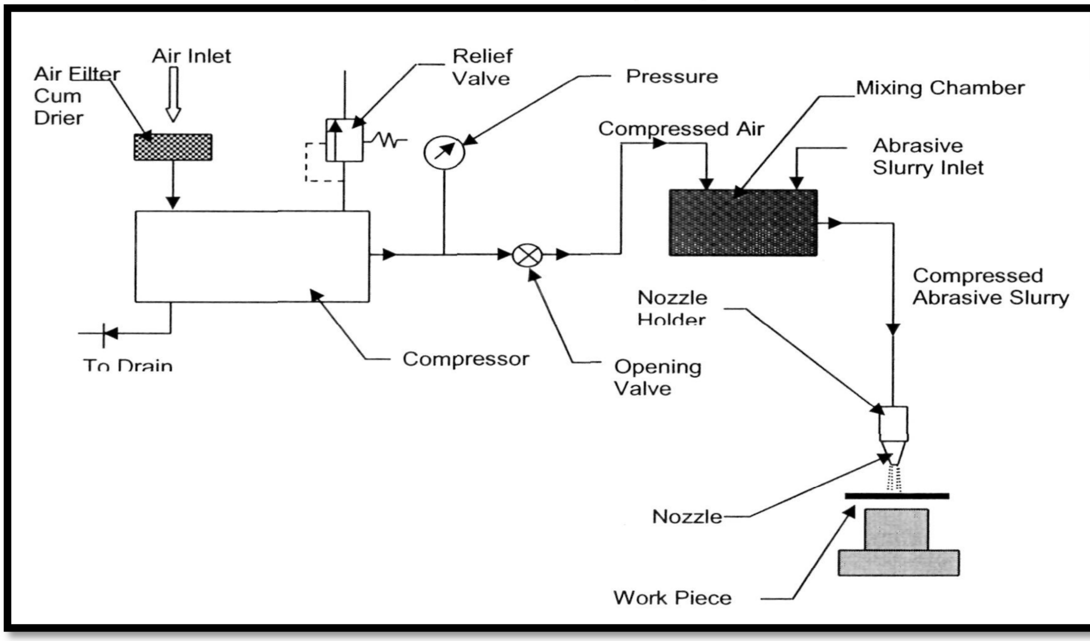

Fig :1 Line Diagram of Abrasive Water jet Machining

3. EXPERIMENTAL SETUP

Aquajet abrasive water jet machine G3020 German Engineering was used for the experiment. the input parameters were taken into consideration with respect to previous papers i.e. water jet pressure, traverse speed and abrasive flow rate.

Fig :2. Abrasive Water jet Machining setup used for the Experiment of EN-8

Table:1 Machining Range of parameters of Abrasive Water Jet machine

Condition	**Range**
Water jet pressure(bar)	4000
Abrasive flow rate(gm/min)	700
Traverse speed(mm/min)	1200
Nozzle diameter(mm)	1
Orifice(mm)	0.35

Water flow rate(liters/min)	4
Abrasive particles(mesh garnet)	80

4. EXPERIMENTAL MATERIAL

EN8 carbon steel is a common medium carbon and medium tensile steel, with improved strength over mild steel, through-hardening medium carbon steel.EN8 steels are generally used in the as supplied untreated condition. and further surface-hardened by induction processes, producing components with enhanced wear resistance. Material in its heat treated forms possesses good homogenous metallurgical structures, giving consistent machining properties. EN-8 is used in manufacture of general purpose axles, shafts, bolts etc.

Table:2. Shows the Chemical composition of EN-8 steel.

Element	Carbon	Silicon	Manganese	phosphorous	Sulphur
Composition	0.36 to 0.44%	0.10to 0.40%	0.60to 1.00%	0.050 max	0.050 max

Table:3. Mechanical properties of EN-8 steel.

Property	Value
Max stress	700-850 n/mm^2
Yield stress	468 n/mm^{2}min
Proof stress	450 n/mm^{2}min
Elongation	16% min
Hardness	201-255 Brinell

5. DESIGN OF EXPERIMENT:

The techniques usually performed in Design Of Experiments to determine the individual and interactive effects of many factors which could affects the results in any design models. The shortest way for this experiment that predicts the outcomes by changing the process parameters which represents by one or more independent variables. Main concepts in the experimental design includes the establishment of validity, reliability, and replicable of the experiments. These concerns may be partially addressed by choosing the independent variables, thus reduction in the risk of measurement errors, and ensuring the documentation of the method is sufficiently explained in detail. Related concerns includes achieving appropriate level of statistical power and sensitivity is observed and it cannot be manipulated of rewritten without proper concerns.

To achieve a perfect cut, it requires that the combinations of the process variables that gives the jet high enough energy to penetrate through the work piece, which are considered for machining and also for further performances. In present study some

process parameters are water jet pressure, traverse speed and abrasive flow rate were preferred as control factors for the experiment and for obtaining the results.

Table:4.The initial input parameters for AWJM of EN-8 material

Parameter	Level-1	Level-2	Level-3
Water jet pressure	3200	3400	3600
Abrasive flow rate	250	350	450
Traverse speed	154	176	220

Table:5.Experimental Design of Taguchi L9 orthogonal array with parameters for AWJM of EN-8 material cutting

Levels	Water jet pressure	Abrasive flow rate	Traverse speed
1	3200	250	154
2	3200	350	176
3	3200	450	220
4	3400	250	176
5	3400	350	220

6	3400	450	154
7	3600	250	220
8	3600	350	154
9	3600	450	176

6. EXPERIMENTAL OUTCOMES

The outcomes of the experiments are kerf width and kerf taper angle of the material. Kerf width is the width of the cut made by the abrasive water jet on the target material. it is measured by the formula given below

$$\text{Kerf width} = \frac{(top\ width + bottom\ width)}{2}$$

Where, Top width is the width of the cut on the surface of the material which is facing the abrasive water jet
Bottom width is the width of the cut at bottom surface

Kerf taper angle is the angle subtended by the kerf taper. It is the deviation of the cut from the original cut. Kerf taper angle is given by the formula as given below

$$\text{Kerf taper angle, } \Theta = \tan^{-1} \frac{(top\ width - bottom\ width)}{2L}$$

Where, L is the length of the cut made by the abrasive water jet

7. RESULTS AND DISCUSSIONS

Table:6 .Results of AWJM of EN-8 material cutting using L9 Taguchi Design of Experiments

Experiments	Input Parameters			Outcomes	
	Water jet pressure	Abrasive flow rate	Traverse speed	Kerf width	Kerf Taper angle
1	3200	250	154	0.473	0.046
2	3200	350	176	0.539	0.012
3	3200	450	220	0.492	0.007
4	3400	250	176	0.448	0.065
5	3400	350	220	0.473	0.005
6	3400	450	154	0.636	0.002
7	3600	250	220	0.447	0.002
8	3600	350	154	0.604	0.005
9	3600	450	176	0.600	0.013

EFFECT OF KERF WIDTH WITH WATER JET PRESSURE, ABRASIVR FLOW RATE, TRAVERSE SPEED

Table:7 . Signal to Noise Ratios of AWJM of EN-8 material

Level	Water Jet Pressure	Abrasive Flow Rate	Traverse Speed
1	6.013	6.827	4.939
2	5.804	5.417	5.59

3	5.271	4.843	6.557
Delta	0.742	1.984	1.618
Rank	3	1	2

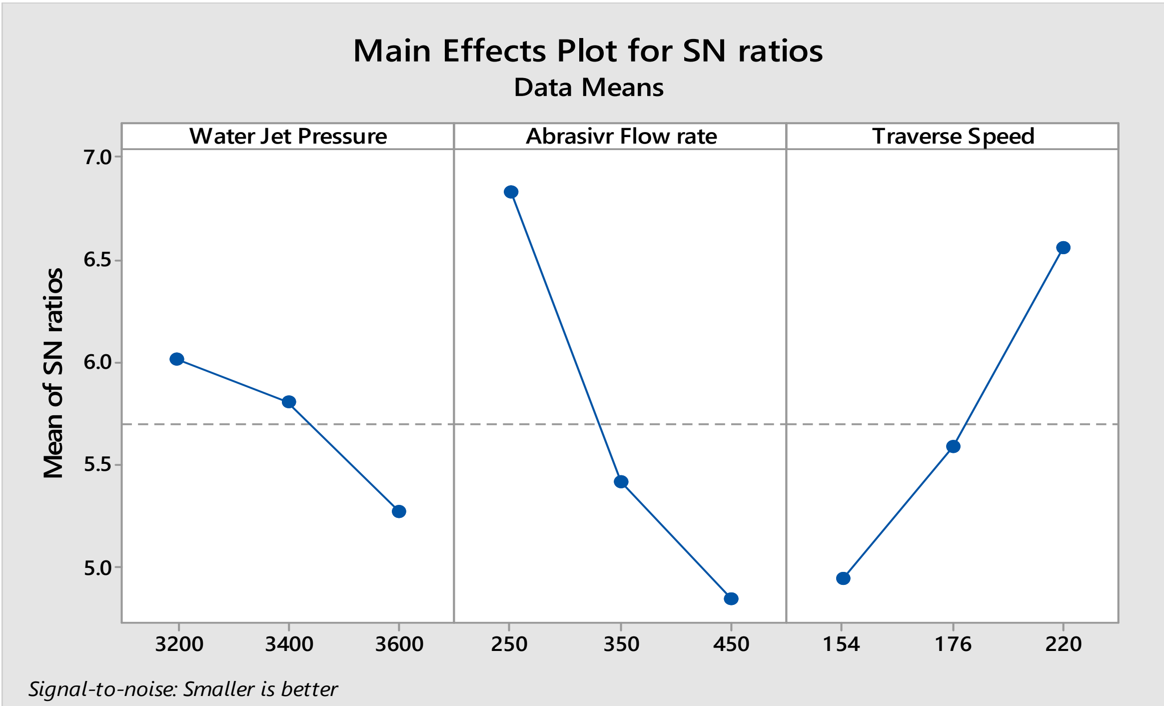

Fig 3:Signal to Noise Graph Kerf width of EN-8 by AWJM Process

EFFECT OF KERF ANGLE WATER JET PRESSURE, ABRASIVR FLOW RATE, TRAVERSE SPEED

Level	Water Jet Pressure	Abrasive Flow Rate	Traverse Speed
1	36.09	45.21	42.35
2	41.25	43.49	33.29
3	45.91	45.91	47.7
Delta	9.82	10.11	14.41
Rank	3	2	1

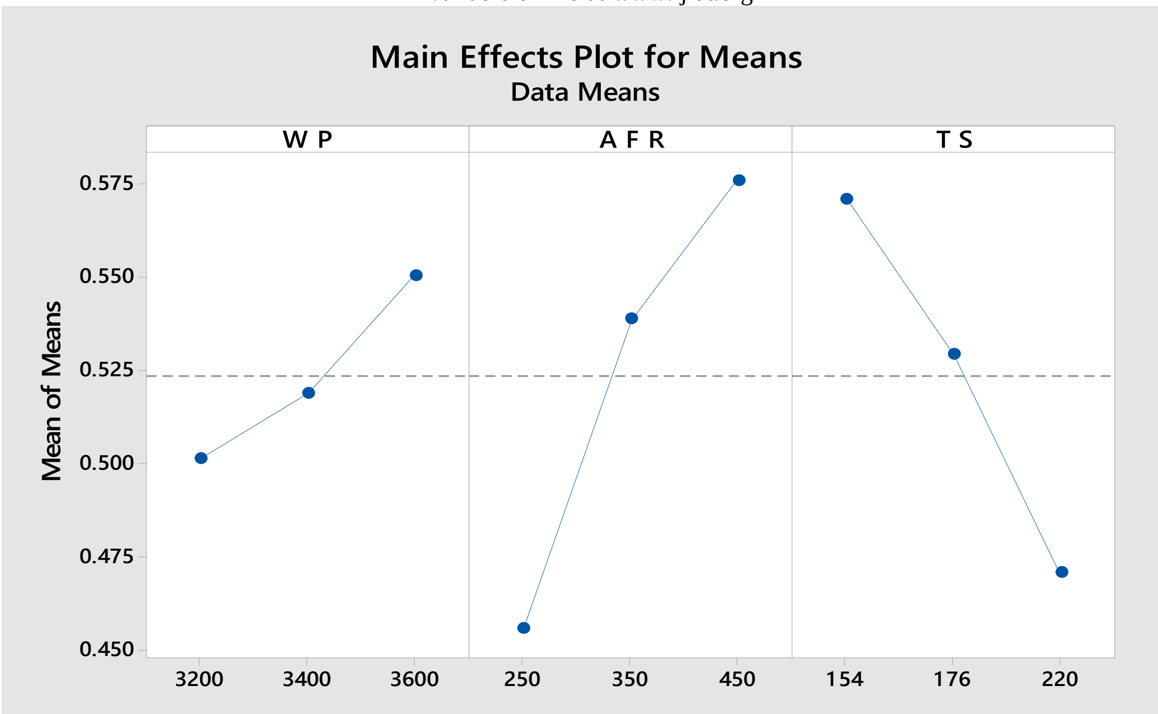

Fig 4: Means Graph Kerf Taper angle of EN-8 by AWJM Process

8. CONCLUSIONS

The present work deals with the abrasive water jet machining of EN-8 Carbon steel materials.the following results were drawn as follows

- The optimum combination for Kerf Width is A1B1C3 ie(water pressure of 3200 bar, Abrasive flow rate of 250 gm/min, Traverse speed of 220mm/min).
- The optimum combination for Kerf Taper angle is A3B3C3 ie(water pressure of 3620 bar, Abrasive flow rate of 450 gm/min, Traverse speed of 220mm/min)

REFERENCES

[1] U Ashok Kumar, G Ajay Kumar, P Laxminarayana, Influence of Process Parameters on Surface Roughness Of En31 By Water Jet Machining , Proceedings of The International Conference on Technological Advances In Mechanical Engineering (ICTAME 2017) ,Page no.217-221

[2] Chithirai, P. S. M. and S. R. N. Mohanna, Abrasive Waterjet Cutting Surfaces of Ceramics - An Experimental Investigation. International Journal of Applied Science, Technology and Engineering Research, 2012. 1(3): p. 52-59.

[3] L.M. Hlavac, I.M. Hlavacova, L. Gembalova, J. Kalicinsky, S. Fabian, J. Mestanek, J. Kmec, V. Madr, Experimental method investigation of the abrasive water jet cutting quality, Journal of Materials Processing Technology 209 (2009) 6190–6195.

[4] J. Kechagias, G. Petropoulos, N. Vaxevanidis, Application of Taguchi design for quality characterization of abrasive water jet machining of TRIP sheet steels, Int. J. Adv. Manuf. Technol. 62 (2012) 635–643.

[5] U Ashok Kumar, P. Laxminarayana “Optimization of Electrode Tool Wear in micro holes machining by Die Sinker EDM using Taguchi Approach” Materials today: proceedings 5(1):1824-1831, January 2018, DOI: 10.1016/j.matpr.2017.11.281

[6] U Ashok Kumar, P. Laxminarayana “Study of surface morphology on micro machined surfaces of AISI 316 by Die Sinker EDM” Materials today: proceedings 4(2):1285-1292. December 2017, DOI: 10.1016/j.matpr.2017.01.149

[7] U Ashok Kumar, P. Laxminarayana, "Study of Tool Wear Optimization in Micro Holes Machining of SS316 by Die Sinker Electrical Discharge Machining", International Journal of Scientific Research in Multidisciplinary Studies, Vol.3, issue.7, pp.1-4, 2017

[8] U Ashok Kumar, P. Laxminarayana “Optimization of process parameters of Material Removal Rate in Micro hole Machining by Die sinker EDM, IOSR Journal

of Engineering (p): 2278-8719 Vol. 07, Issue 07 (July. 2017), ||V1|| pp. 61-65

[9] Milan Brozek, "Steel cutting using Abrasive water jet", Engineering for rural development, Jelgava, 24.-26.05.2017

[10] Natarajan Yuvraj, Murugusen Pradeep Kumar, "Investigation of process parameters influence in Abrasive water jet cutting of D2 steel", Materials and Manufacturing Processes, 32:2, 151-161, DOI:10.1080/10426914.2016.1176183

[11] Piotr Loschner, Krzysztof, Poitr Nieslony, "Investigation of the effect of cutting speed on surface quality in Abrasive water jet cutting of 316L stainless steel", International Conference on Manufacturing Engineering and Materials, ICMEM 2016, Procedia Engineering 149 (2016) 276-282.

[12] Mohammad S.Alsoufi, Dhia K.Suker, Abdulaziz S.Alsabban, Sufyan Azam, "Experimental study on surface roughness and micro-hardness obtained by cutting Carbon steel with Abrasive water jet and Laser Beam Technologies", American Journal of Mechanical Engineering, 2016, vol. 4, no.5, 173-181, DOI:10.12691/ajme-4-5-2

[13] R.Kovacevic, "Surface texture in Abrasive water jet cutting", Journal of Manufacturing systems, volume 10/No.1.

[14] Gaurav D.Sonawane, Radhey M.Bachhav, "Abrasive water jet machining –A Review", IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), e-ISSN:2278-1684, p-ISSN: 2320-34X, vol:12, issue 4 ver.II (jul.-Aug.2015), PP 44-52.7

[15] Wei Zhan, Chuwen Guo, "Topography and microstructure of the cutting surface machined with abrasive water jet", Int J Adv Manuf Technol (2014) 73:941, DOI 10.1007/s00170-014-5869-5.