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Experimental Optimization of Kerf Taper in EN-8 by Abrasive water Jet Machining Process

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***Abstract:** In this paper, the cutting of medium carbon steel (EN-8) with respect to different parameters i.e water jet pressure, abrasive flow rate and traverse speed, were taken for abrasive water jet machining process. Kerf taper of EN-8 steel are measured with respect to the above-mentioned input parameters by using Taguchi L9 array Design of Experiments. From Taguchi methods smaller the better is consider for the optimization in kerf angle*
***Keywords:** Kerf Taper, Taguchi L9 Array, Abrasive water pressure, Traverse speed.*

I. INTRODUCTION

Abrasive water jet machining , where the material is removed by the principle of erosion .AWJM with 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 up to 50000 bars and above as per the requirement. 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. The Abrasive Jet 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. 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. 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. 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.

II. EXPERIMENTAL METHODOLOGY

A. *Experiment Setup*

Aquajet abrasive water jet machine G3020 with CNC Water jet Cutting machine, HP pump & accessories with highest quality Tool design and manufacture water jet cutting machine with an exposure to German Engineering were shown in fig.1 and specifications of AWJM were Table.1

Fig: 1 Abrasive Water jet machining Process Setup

TABLE: 1.THE SPECIFICATION OF ABRASIVE WATER JET MACHINE

Input Parameters	**Range**
Water jet pressure(bar)	4000 bar
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

B. 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 can be further surface-hardened by induction processes, producing components with enhanced wear resistance. The materials in its heat treated forms possesses good homogenous metallurgical structures, giving consistent machining properties used in manufacture of general purpose axles, shafts, bolts etc.

TABLE: 2. CHEMICAL COMPOSITION OF EN-8 STEEL.

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

TABLE: 3.MECHANICAL PROPERTIES OF EN-8 STEEL.

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

C. Design of Experiment

The techniques usually performed in Design of Experiments (D.O.E) by taguchi L9 Orthogonal Array to determine the individual and interactive effects of many factors which could affect the results in any design models. 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 is considered for machining and also for further performances. In present study some process parameters were Water Jet Pressure, Abrasive flow rate, traverse speed, preferred as control factors for the experiment and for obtaining the results in kerf taper optimization

TABLE: 4. EXPERIMENTAL INPUT PARAMETERS FOR ABRASIVE WATER JET MACHINING PROCESS

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. DESIGN OF EXPERIMENT PLAN BY TAGUCHI L9 ARRAY FOR AWJM OF EN-8

Experiments	**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

D. Experimental Outcomes

Kerf taper formula as given below

Kerf Taper = [top width+ bottom width] /2L

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

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

III.RESULTS AND DISCUSSIONS

TABLE: 6. EXPERIMENT RESULTS OF KERF TAPER BY TAGUCHI L9 FOR AWJM OF EN-8

EXPT	Input Parameters			Output
	Water Jet Pressure	Abrasive Flow rate	Traverse Speed	Kerf Taper
1	3200	250	154	0.00084
2	3200	350	176	0.00221
3	3200	450	220	0.00013
4	3400	250	176	0.00114
5	3400	350	220	0.00093
6	3400	450	154	0.00004
7	3600	250	220	0.00004
8	3600	350	154	0.00009
9	3600	450	176	0.00022

Table 6 shows the results of kerf taper by Abrasive water jet machining process on EN-8 materials where 9 experiments were performed to get the optimum value of Kerf Taper

TABLE: 7. RESPONSE TABLE FOR SIGNAL TO NOISE RATIOS SMALLER IS BETTER

Level	Water Jet Pressure	Abrasive Flow rate	Traverse Speed
1	64.12	69.45	**76.80**
2	69.15	64.89	61.71
3	**80.68**	**79.61**	75.44
Delta	16.56	14.72	15.09
Rank	1	3	2

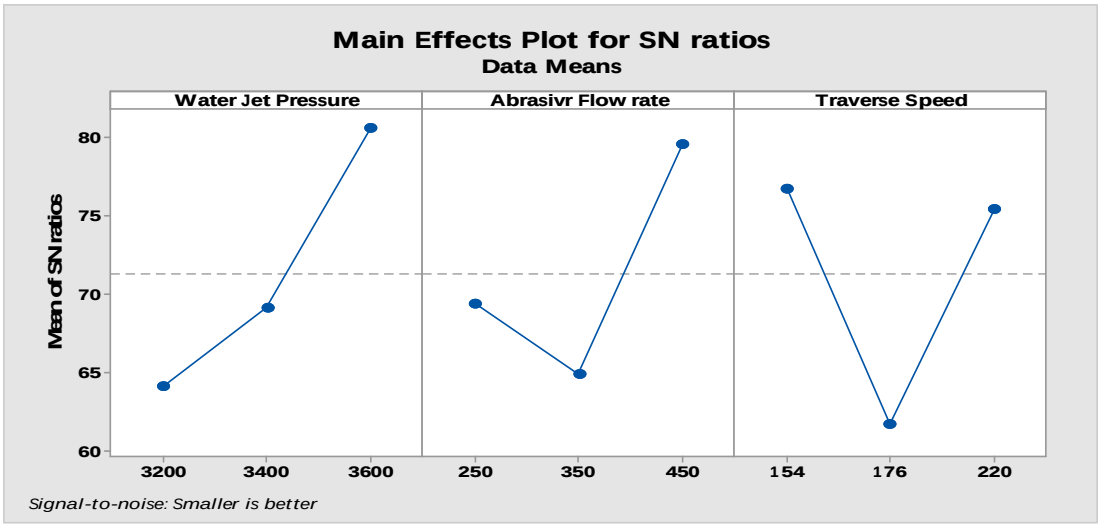

Fig: 2 Main Effects Plot for SN ratios Kerf Taper versus Water Jet Pressure, Abrasive Flow rate, Traverse Speed

From Table.7 shows the response of signal to noise ratio in which smaller the best is consider for the Kerf taper.
And from Fig.2 represent the Main Effects Plot for SN ratios Kerf Taper versus Water Jet Pressure, Abrasive Flow rate, Traverse Speed in which the combination is A3-B3-C1
From the combination A3-B3-C1 it is clearly shows that its do not match with taguchi L9 array experiment so there is need to do confirmation test by the equation as follows.

$$Y_{opt} = m + \left(m_{Aopt} - m\right) + \left(m_{Bopt} - m\right) + \left(m_{Copt} - m\right).$$

IV. CONCLUSIONS

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

A. The optimum combination for Kerf Taper angle is A3B3C1 i.e. (water pressure of 3620 bar, Abrasive flow rate of 450 gm/min, Traverse speed of 154mm/min)
B. From the confirmation test the value of Kerf taper is 0.00014 mm for combination A3B3C1 i.e. (water pressure of 3620 bar, Abrasive flow rate of 450 gm/min, Traverse speed of 154mm/min)

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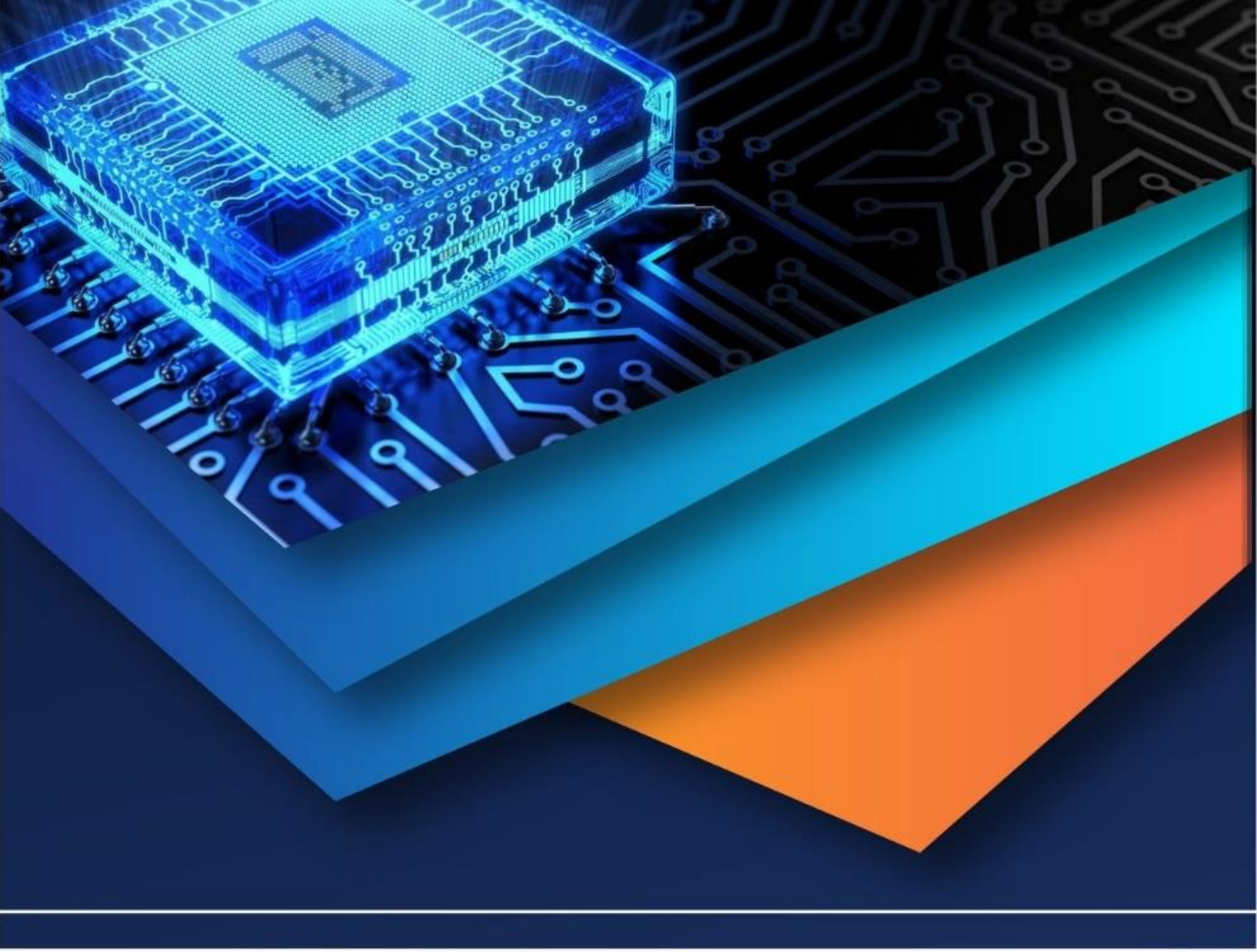

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