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Investigating Effect of Various Parameters in Abrasive Jet Machining on MRR

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ABSTRACT:
In this thesis, different experiments are performed on mild steel work piece by varying various parameters such as exit water velocity and feed rate to determine Material Removal rates. The parameters considered are Feed Rate 200mm/min, 300mm/min, 600mm/min, Exit water velocity 140mm/min, 250mm/min, 350mm/min. Optimization is done using Taguchi technique to determine better parameters to obtain maximum material removal rates. CFD analysis is done on the nozzle by applying the exit water velocities to determine pressure, outlet velocity and mass flow rates. Modeling of nozzle is done in Creo and CFD analysis is done in Ansys. Theoretical calculations are done to determine mass flow rates and compared with that of analytical results.

LITERATURE REVIEW:
In this review the experimental analysis of Abrasive jet machining is discussed. Dr. M. Sreenevasa Rao [3] reviewed that In gulli C. N. (1967) was the first to explain the effect of abrasive flow rate on material removal rate in AJM. Along with Sarkar and Pandey (1976) concluded that the standoff distance increases the MRR and penetration rate increase and on reaching an optimum value it start decreasing. J.Wolak (1977) and K. N. Murthy (1987) in Vestigated that after a threshold pressure, the MRR and penetration rate increase with nozzle pressure. The maximum MRR for brittle and ductile materials are obtained at different impingement angles. For ductile material impingement angle of 15-20 results in maximum MRR and for brittle material normal to surface results maximum MRR.

EXPERIMENTAL SET-UP:
Experimentation is conducted by machining mild steel piece by varying the process parameters considered Exit water velocity and Feed rate and their performance is measured on the material removal rate. The specifications of the equipment used for machining is discussed below.

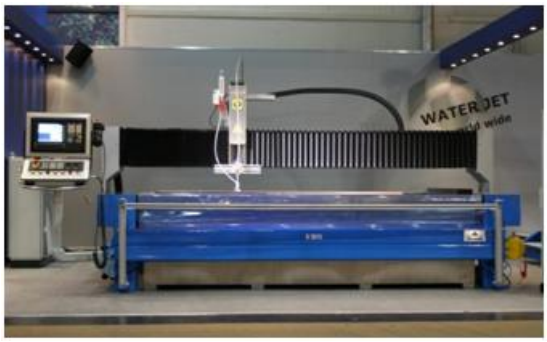

Fig – Water Jet Machine Model Number: S3015

WORK PIECE SIZE:
A rectangular piece of Mild Steel material with dimensions 100mm length, 16mm width and 8mm thickness is taken and machined using water jet machining by varying the process parameters Feed rate. The Abrasive type used is garnet and pressure is maintained constant at 60,000psi. The parameters are varied as per L9 orthogonal array using Taguchi Technique.

PARAMETERS USED FOR MACHINING

JOB NO.	FEED (mm/min)	WATER EXIT VELOCITY (mm/min)
1	200	140
2	200	250
3	200	350

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4	300	140
5	300	250
6	300	350
7	600	140
8	600	250
9	600	350

Table – Process Parameters taken for machining

Material----------MS

Feed Rate(Tool Speed) ---- 200 mm/min, 300mm/min & 600mm/min

Water Jet Velocity ----- 140mm/min, 250mm/min & 350mm/min

Sand Feed------- 300g/min

Software for design ----- Autocad

Software For CNC Coding ------Item CAD, Most 2D.

Water Pressure for Cutting -----60,000psi

Water consumption ----200ltrs/hr.

Fig – Final Machined Pieces

CALCULATION OF MATERIAL REMOVAL RATES:

To calculate material removal rates, the time taken for machining and the weight of the work piece are measured as per table given below.

FEED (mm/min)	WATER EXIT VELOCITY (mm/min)	Time Taken (Sec)	Weight (gms)
200	140	550	1180
200	250	478	1090
200	350	389	942
300	140	495	867
300	250	426	710
300	350	335	550
600	140	313	303
600	250	214	105
600	350	80	15.2

Material removal rate MRR = $(W_b - W_a) / t * \rho$

Where

W_b = Weight of work piece before machining (Kg)

Wa = Weight of work piece after machining (Kg)

t = Machining Time (Secs)

ρ =Density of work piece (Kg/mm^3)

The MRR Values Calculated From The Experimental Data Is As Shown In Below Table.

FEED (mm/min)	WATER EXIT VELOCITY (mm/min)	MRR (mm^3/sec)
200	140	16.213
200	250	23.98
200	350	48.466
300	140	19.301
300	250	46.94
300	350	60.84
600	140	100.52
600	250	117.86
600	350	142.99

Table – Calculated MRR values for experimental data

OPTIMIZATION OF MACHINING PARAMETERS FOR HIGHER MATERIAL REMOVAL RATES USING MINITAB SOFTWARE

In this project, Taguchi method is used to optimize the process parameters Feed Rate and Exit Water Velocity for higher material removal rates. The optimization is done in Minitab 17 software.

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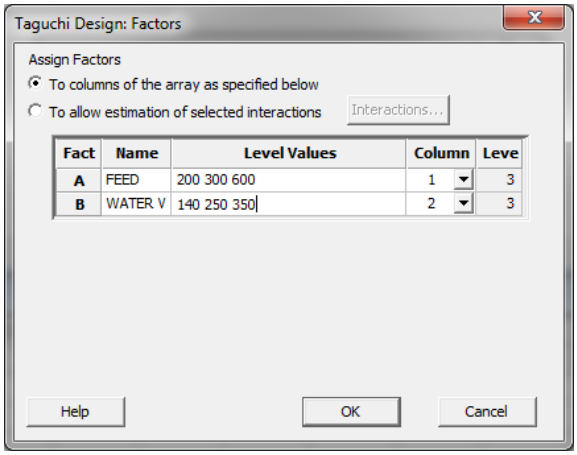

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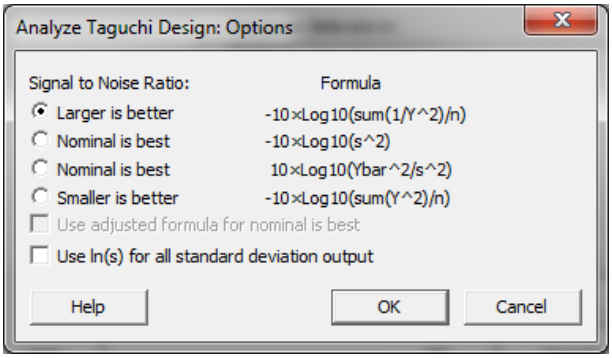
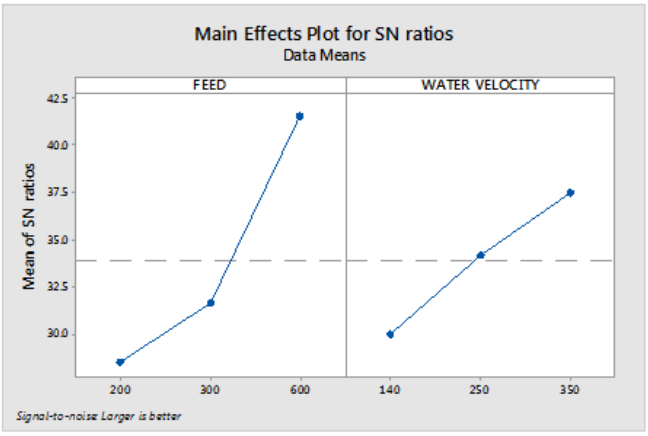


Results Table

Worksheet 1 ***

	C1	C2	C3	C4
	FEED	WATER VELOCITY	MRR	SNRA1
1	200	140	16.213	24.1973
2	200	250	23.980	27.5970
3	200	350	48.466	33.7087
4	300	140	19.301	25.7116
5	300	250	46.940	33.4309
6	300	350	60.840	35.6838
7	600	140	100.520	40.0450
8	600	250	117.860	41.4273
9	600	350	142.990	43.1061



Effect of machining parameters on MRR for S/N ratio
Regardless of the category of the performance characteristics, a greater S/N value corresponds to a better performance. Therefore, the optimal level of the machining parameters is the level with the greatest value.

Feed Rate:

The effect of parameter feed rate on MRR is shown above figure S/N ratio. So the optimum feed rate is 600 mm/min.

Water Velocity:

The effect of parameters Water Velocityon MRR is shown above figure for S/N ratio. So the optimum water velocity is350 mm/min.

THEORETICAL CALCULATIONS FOR MASS FLOW RATE

Mass Flow Rate $M_w = \rho_w * Q_w = \rho_w * \Pi/4 * d_o^2 * V_w$
Where ρ_w = Density of water
d_o = diameter of nozzle
V_w = Exit Water Velocity

CFD ANALYSIS OF NOZZLE

FLUID - WATER

VELOCITY – 140mm/min (0.00233333m/s)

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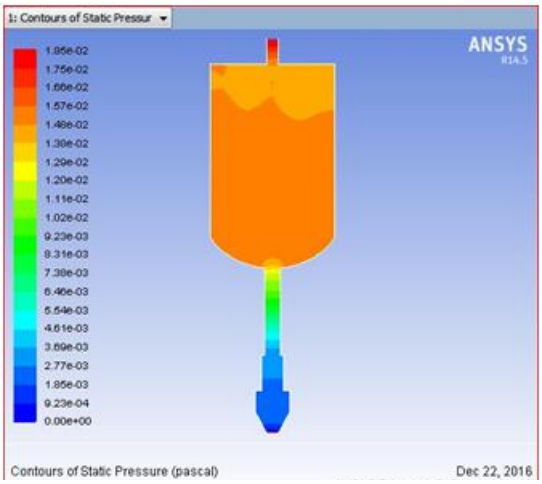


Fig – Contours of Static Pressure nozzle

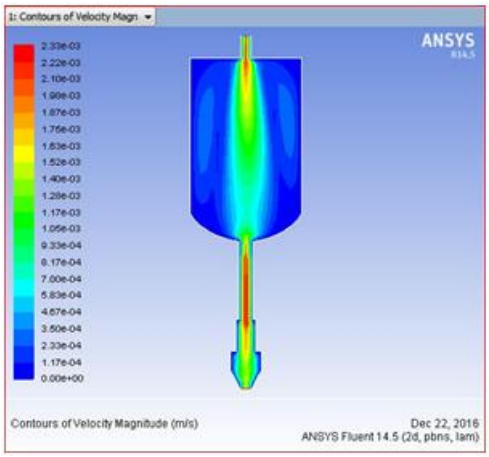


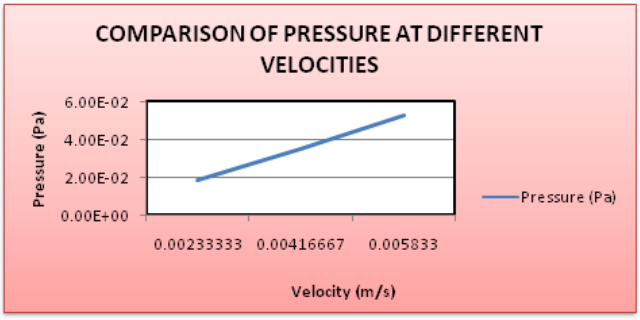
Fig – Contours of Velocity Magnitude nozzle

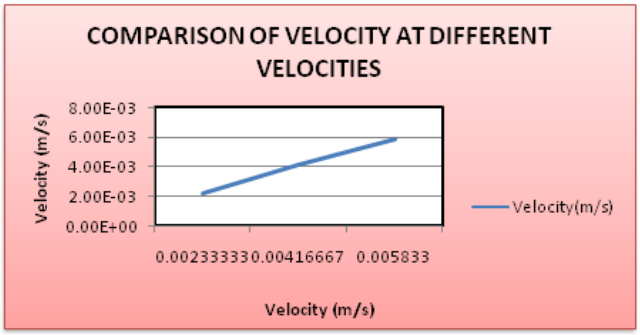
Mass Flow Rate	(kg/s)
inlet	0.023291299
interior-_trm_srf	0.49106154
outlet	-0.023291906
wall-_trm_srf	0
Net	-6.0722232e-07

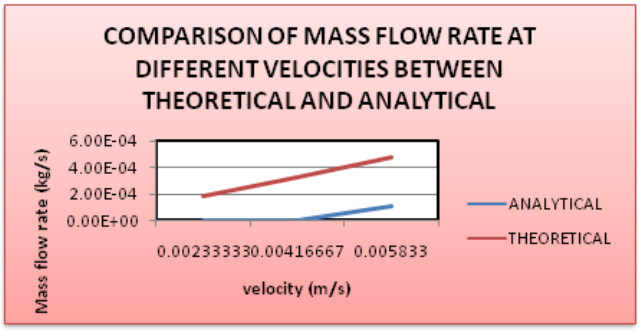
Mass Flow Rate

RESULTS TABLE

Velocity (m/s)	Pressure (Pa)	Velocity (m/s)	Skin friction coefficient	Wall shear stress (Pa)	Mass flow rate (kg/s)
0.0233333	1.85e-02	2.23e-03	1.53e-03	9.39e-04	-6.0722232e-07
0.00416667	3.50e-02	4.17e-03	2.76e-03	1.60e-03	-2.1606684e-06
0.005833	5.30e-02	5.83e-03	3.87e-03	2.37e-03	0.0001105052564







CONCLUSION:

From the experimental results and the Taguchi method, it can be observes that to attain maximum removal rates, the parameters feed rate and exit water velocity should be more. So the optimum feed rate 600 mm/min, and the optimum Exit Water Velocity is 350mm/min.By observing the CFD analysis results, the pressure and the mass flow rates are increasing by increase of exit water velocity. The mass flow rate values found analytically are similar with that of theoretical calculations.

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