STATISTICAL PARAMETRIC STUDY OF ABRASIVE JET MACHINING

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***Abstract*— This paper deals with statistical modeling study of abrasive jet machining process influence of process parameters (material removal rate). Diameter of holes of glass plates using different types of abrasive used for the experimental values. The results of the present work are used to discuss the validity of proposed model. With the increase in nozzle tip distance (NTD), the top surface diameter and bottom surface diameter of hole increases as it is in general observation of abrasive jet machining process. Present study has been introduced a statistical model and the obtained results analysis obtained through dual parametric Z-Test and ANOVA for experimental studies. This paper will help students, manufactures and researchers, to understand policy makers and optimized working parameters widely.**

***Index Terms* — AJM,Z-Test, Anova, Mixing Ratio, Statistical, MRR,SOD,U.B**

I. INTRODUCTION

For cutting, cleaning, polishing, deburring, etching, drilling and finishing like operations AJM is applied (1). The parameters like Standoff Distance, abrasive contain gas, Pressure, kind of Abrasive, grain size, ratio of gas-abrasive etc. are designed. [2] Neema & Pandey (1977) proposed an equation for M.R.R on work of deformation during indentation. $Q = k\times N \times d^3 \times v^{3/2}(\rho a/12\sigma y)$ Where k is a constant; N is the number of abrasive particles taking quite a time; d= the size or diameter of an abrasive particle; fa= the density of the abrasive material; v= the velocity of the abrasive particle; and σ y, =the yield stress of the work material. [3]. Erosion is depends on Speed and angle of impact, ductility or brittleness the impinging particles, elasticity of the material; of the material and ,shape, geometry of impinging particles ,impinging particle diameter to work-material, thickness ratio, average flow stress, material and density and Distance between the nozzle mouth and work piece Carbon dioxide, nitrogen, air. Considered as Carrier Gas (Medium).Air is most widely used. But oxygen never used as a carrier gas due to fire hazards. Dr.A. K. Paul &P. K. Roy (1987) have been investigated MRR, MRF, AFR experimentally .Conducted Experimentation on the cutting of Porcelain with Sic Srikanth et al., International Journal of Advanced Engineering Technology E-ISSN 0976-3945 Int J Adv Engg Tech/Vol. V/Issue II/April-June,2014/18-24 abrasive particles at. various Air pressures. Observed that MRR has increased with increase in grain size and increase in nozzle diameter [4]. Varma & Lal (1984) explained about the effect of Nozzle Pressure on MRR and Effect of SOD on MRR for various Mixing ratios. The Variation in Pressure is clearly indicated with the help of graphs [5].

II. PROJECT METHODOLOGY

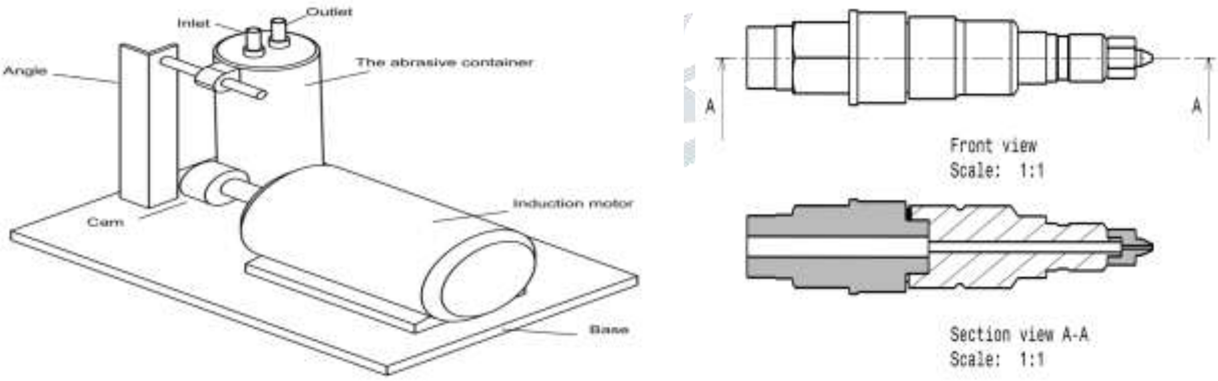


Fig. 1-The vibrator assembly & Nozzl

Characteristics of different parameters-

Stand off distance	0.25 to 15 mm (8mm generally)
Work material	Non Metals like glass, ceramics, and granites. Metals and alloys of hard materials like germanium, silicon etc
part application	Drilling, cutting, deburring, cleaning

Medium	Air , CO_2 ,N_2
Abrasive	SiC, Al_2O_3 (of size 20µ to 50µ)
Flow rate of abrasive	3 to 20 gram/min
Velocity	150 to 300 m/min
Pressure	2 to 8 kg/cm2
Nozzle size	0.07 to 0.40 mm
Material of nozzle	WC, Sapphire
Nozzle life	12 to 300 hr

Table 2 Characteristics of different parameters

Glass was used as a test specimen, was cut into square and rectangular shape for machining on AJM. Specimens were cleaned using air jet and weighed on a sensitive scale, accurate to 0.001 gm. The compressed air from the compressor enters the mixing chamber partly prefilled with fine grain abrasive particles. The vibratory motion of the air created in the mixing chamber carries the abrasive particles to the nozzle through which it is directed on to the work-piece. The nozzle and the work-piece are enclosed in a working chamber with a Perspex sheet on one side for viewing the operation diameters [6]. This type of set-up has the advantage of simplicity in design, fabrication and operation. The equipment cost is much less except the compressor. The machine work-piece was then removed, cleaned and weighed again to determine the amount of material removed from the work piece. The size of hole at the top surface and bottom surface was measured and the results were tabulated.

III. EXPERIMENTAL SET-UP-

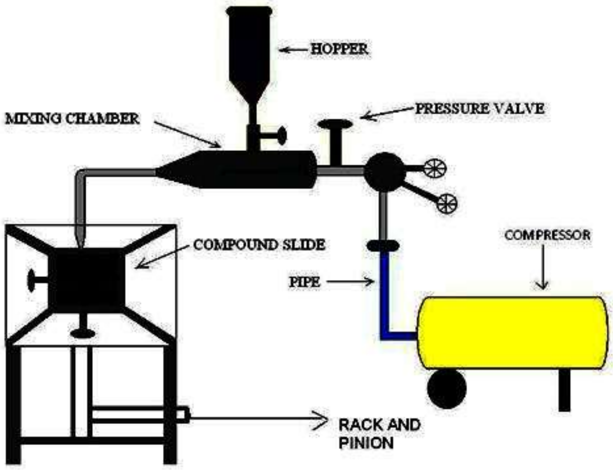


Fig 3-Schematic Diagram of Experimental Set-Up

Compressed air enters the mixing chamber partly prefilled with fine grain abrasive particles. The vortex motion of the air created in the mixing chamber carries the abrasive particles to the nozzle through which it is directed on to the work-piece. The nozzle and the work-piece are enclosed in a working chamber with a Perspex sheet on one side for viewing the operation [7]. The abrasive particles used were silicon carbide (grain size 62 microns and 125 microns). The nozzle material was stainless steel and the nozzles used were of diameters 1.76 mm and 1.61 mm. This type of set-up has the advantage of simplicity in design, fabrication and operation. The equipment cost is much less except the compressor. The mixture ratio is controlled by the inclination of the mixing chamber.

IV. RESULT & DISCUSSION-

The mixture ratio is defined as Mp/Ma± Mp, Where m_p is the mass flow rate of the abrasive particles and m_a the mass flow rate of air.

S. No.	Gas pressure	Material removal rate(mg/min)
1	5	18
2	6	21
3	7	23
4	8	26

Table 3 Effect of Pressure On Material Removal Rate (MRR)

z-test for two independent samples / Two-tailed test:

95% confidence interval on the difference between the means:

[-19.398 ,	-13.269 [
Difference	-16.333
z (Observed value)	-10.447
|z| (Critical value)	1.960
p-value (Two-tailed)	< 0.0001
alpha	0.05

Test interpretation:

H0: The difference between the means is equal to 0.

Ha: The difference between the means is different from 0.

As the computed p-value is lower than the significance level alpha=0.05, one should reject the null hypothesis H0, and accept the alternative hypothesis Ha.

The risk to reject the null hypothesis H0 while it is true is lower than 0.01%.

Summarystatistics:

Variable	Observations	Minimum	Maximum	Mean	Std. deviation
5	3	6.000	8.000	7.000	1.000
18	3	21.000	26.000	23.333	2.517

Significance level (%): 5

As the distance between the face of nozzle and the working surface of the work increases, the diameter of hole also increases because higher the nozzle tip distance allows the jet to expand before impingement which may increase vulnerability to external drag from the surrounding environment. It is desirable to have a lower nozzle tip distance which may produce a smoother surface due to increased kinetic energy.

S.No	Nozzle tip distance (mm)	Diameter of hole(mm)
1	0.79	0.46
2	5.00	0.64
3	10.01	1.50
4	14.99	2.01

Table 2.2 Effect of NTD on diameter of hole

Applying ANOVA

Confidence interval (%): 95

Tolerance: 0.0001

Summary statistics:

Variable	Observations	Minimum	Maximum	Mean	Std. deviation
0.75	3	5.000	14.890	9.977	4.945
46	3	2.020	1050.000	371.673	588.239

Correlation matrix:

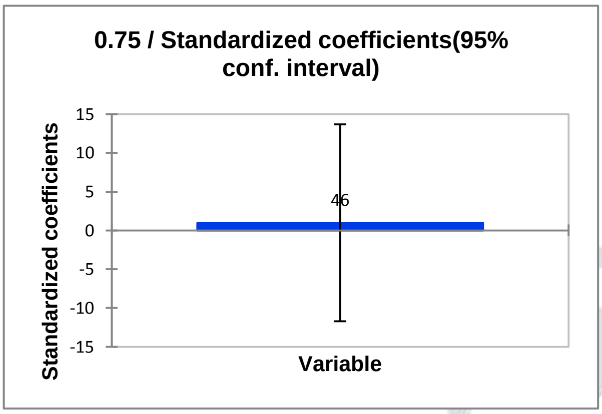
	46	0.75
46	**1**	-0.041
0.75	-0.041	**1**

Regression of variable 0.75:

Goodness of fit statistics (0.75):

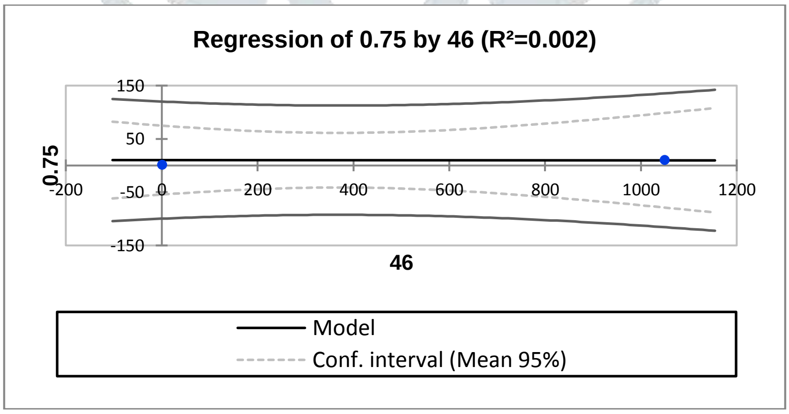
Observations	3.000
Sum of weights	3.000
DF	1.000
R^2	0.002

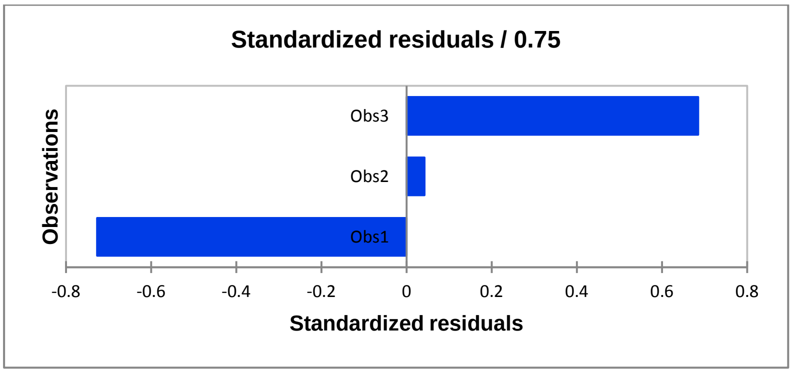
Adjusted R^2	-0.997
MSE	48.831
RMSE	6.988
MAPE	45.580
DW	1.005
Cp	2.000
AIC	12.369
SBC	10.566
PC	4.992



Predictions and residuals (0.75):

bservation	Pred(0.75)	Residual	Std. residual	Std. dev. on pred. (Mean)	Lower bound 95% (Mean)	Upper bound 95% (Mean)	Std. dev. on pred. (Observation)	L. B 95% (Observation)	U.B 95% observation
Obs1	10.082	-5.082	-0.727	4.796	-50.854	71.019	8.475	-97.606	117.771
Obs2	9.744	0.296	0.042	6.982	-78.966	98.454	9.878	-115.767	135.256
Obs3	10.103	4.787	0.685	5.091	-54.584	74.791	8.646	-99.752	119.958





V. CONCLUSION

It is found that the regression of 0.75 given optimum MRR with U.B 117.77. We investigated the various process parameters of AJM by using different types of work material and abrasives by changing the other parameters of AJM like pressure, Nozzle tip distance, size of abrasive grains. From that we can decide the most appropriate condition for Material Removal Rate (MRR).

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